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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

Duties, Qualifications and Salary.

The above caption is meant to be restricted in application to the position to be occupied by any safety officers appointed to foundries if the Home Office make good their case. If this comes to pass, we estimate that the foundry industry will be called upon to find £250,000 per annum for salaries, against a credit of problematic cash value. We hope, but do not expect, that there will be a large scale reduction in the staff of the Factory Inspection Department, as obviously with a "Resident Inspector" there should be a diminished need for external guidance (or should it be interference). The no-longer-necessary officials would possess exactly the *theoretical* qualifications needful for the successful performance of the duties of Safety Officer, that is the interpretation into works practice the innumerable Home Office Regulations.

So far as we can visualise the duties of the proposed Safety Officers, they will relate to the prevention of accidents by (1) the rational interpretation of existing factory acts; (2) the inculcation of "safety-first" principles; (3) the re-organisation or modification of works conditions to render them "safer"; (4) welfare work (including ambulance work); and (5) the keeping of pertinent records.

For the carrying out of duty (1) a man having the mentality of a solicitor; coupled with the inventiveness of a high-class mechanic, would apparently adequately meet the conditions. For (2) however the teaching instinct seems to be the paramount virtue, whilst for (3) the attributes are just those for which any direction would be wise to pay highly. Obviously, tampering with existing manufacturing conditions can only be done by those having foresight, a profound knowledge of existing conditions, and courage to shoulder responsibility. For instance, a recently introduced process in connection with ferrous metallurgy demands the introduction of certain salts into the liquid metal. Unpleasant conditions result. Is the "Safety Officer" to be taught at the works expense a considerable section of the metallurgy of iron in order to give a rational judgment as to whether large-scale experiments are worth while? Again, certain foundries use horse manure in the loam mixtures. The "Safety Officer" may have been told that certain managements have replaced this by sawdust. Is his position to be sufficiently important that he could shoulder the responsibility for any loss (and this could be truly serious) that might result from his recommendations? The duties indicated by (4) nowadays call for a special training, preferably associated with a lengthy practical experience. Being a non-productive department it resolves itself into an organism for replacing personal contact and good fellowship between master and man, but at an economic cost. Duty (5) calls for no comment.

The question of salary for such an individual primarily depends upon the size of the works. For a very large works, if he is to effect any real improvement he must occupy a position between the general manager and the departmental chiefs, whilst in medium-sized concerns (say, 50 employees) he should rank above a foreman. Obviously, to control the stacking of pig-iron, the weighting down of top-parts, the character of the gangways between the boxes, and similar questions of organisation, the "Officer" must at least control the foreman if not the manager. We candidly believe that of all the propositions ever put forward by a responsible Government department, the appointment of "Safety Officers" for the foundry industry is the most fatuous, on the following grounds: (1) The largest works have adequate organisations covering the ground sought to be improved, and the introduction of the new "name" (for that is all it will amount to) will not be ameliorative, because it will rob the general manager of the most pleasant part of his job, and eliminate his closest point of contact between the men and himself; (2) in smaller concerns it will create friction between the foreman and his new "chief," who has always the ethical argument against the former's economic. This conduces to a generally contagious mental strain in the works definitely productive of accidents.

The appointment of "Safety Officers" is the wrong method of attack. The Home Office is apparently not understaffed (one factory recently had visits from five officers in one week)—and each inspector should be an enthusiastic safety-first propagandist, rather than a mere detective spending his time pointing out that whitewash does not mean white paint or that lavatory doors must have locks.

Pull-Through Moulding Machines.

The Pull-Through moulding machine is particularly adapted both for the production of moulds from deep single patterns, as also for the moulding of small objects, such as rollers, radiator nipples and similar repetition work.

In this type of machine the pattern is, of course, stripped from below whilst the flask remains on the machine. In the separation of the pattern and mould the latter is supported by a stripping plate, so that any crumbling of parts of the mould is avoided as far as this is possible, this arrangement renders the Pull-Through machine particularly adaptable for steep patterns, which permit but slight taper. Obviously the design of the pattern and pull-through plate is somewhat costly, so that this type of machine is higher in initial cost than the turn-over plate moulding machine, but in view of the rapid and exact work which is possible with the Pull-Through machine, the additional capital, outlay may well be justified.

The Pull-Through is, for the most part, a special machine and designed for a particular duty, such, for example, as cylinders, fire-bars, ribbed pipes, boiler sections, plain cast pipes, etc. The machines, however, can be constructed so that the pattern arrangement can be removed, and the machine then used for the moulding of other objects in flasks of the same size, by the aid of the pull-through method.

The machines illustrated are representative of a very full range built by Badische Maschinenfabrik u. Eisengiesserei, of Durlach, Germany.

Machines with small lifts are provided with an eccentric and a lever, those with long lifts being equipped with toothed bar, pinion and hand-wheel. The hand-ramming Pull-Through machine with a special lift-off is designed for the production of small belt pulleys with curved arms.

The table plate with the stripping arrangement is removable and can be interchanged; furthermore, the boss and arms can be taken out alone, so that by simply changing the arms, the pattern for the other half of the flask is ready

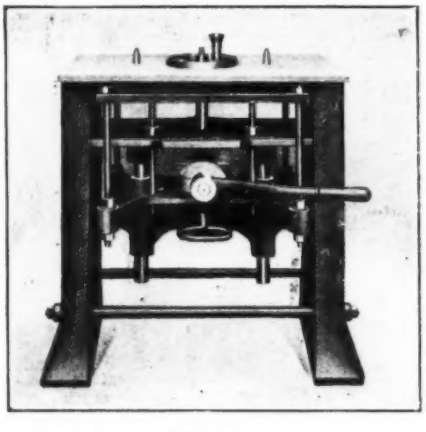

FIG. 1.
Machine ready to receive flask.

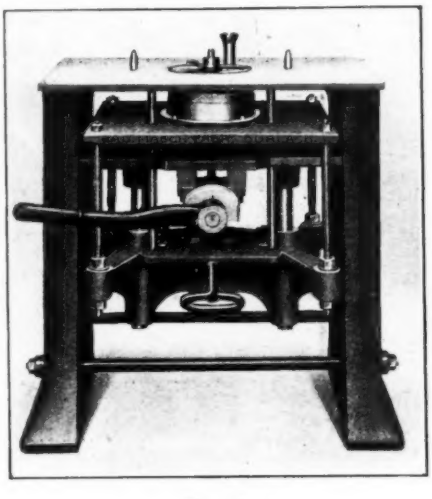

FIG. 2.
Here the rim has been stripped.

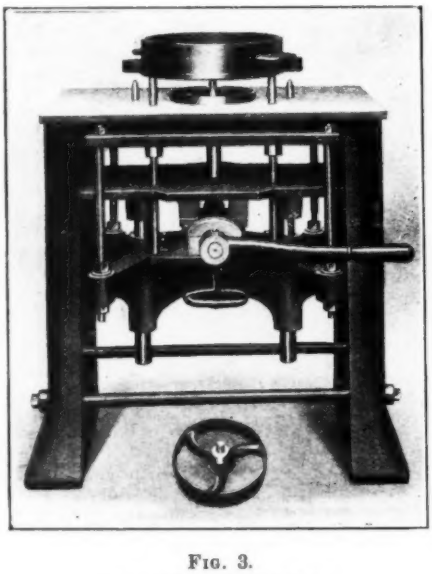

FIG. 3.
Final position with flask lifted.

FIGS. 1 TO 3 SHOW THE OPERATIONS CARRIED OUT IN THE MACHINE MOULDING OF A PULLEY.

for moulding. Our illustrations show the operation of moulding a half-flask. Fig. 1, illustrates the machine ready to receive the flask, in Fig. 2 the rim is stripped, whilst in Fig. 3 the final position is shown with the lifted flask.

Ramming is done by hand. All working positions of the machine are controlled by the simple movement of the hand lever and turning of the hand wheel seen in front of the machine. The special arrangement for lifting the moulds after the pattern has been pulled through from below obviates any damage to the mould whilst it is being taken off the pull-through plate.

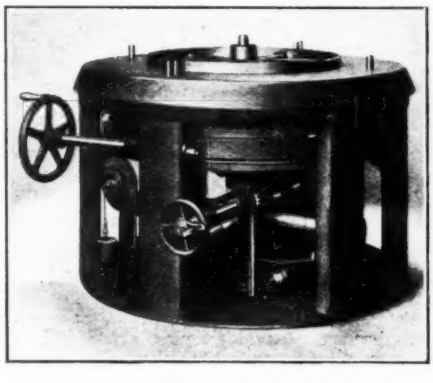

FIG. 4.—TELESCOPIC PULLEY MOULDING MACHINE.

It is generally recognised that if belt pulleys are to be produced with accuracy, evenness and profitably, machine moulding is a *sine qua non*, and to meet this requirement Badische Maschinenfabrik have developed two systems of pulley moulding machines—the loose-pattern and the telescopic types.

The loose-pattern type comprises a table resting on a cast-iron support arranged to take the loose-pattern rings. Naturally, a special set of patterns is required for each size of pulley. The set is fixed as follows: The rim pattern is secured to

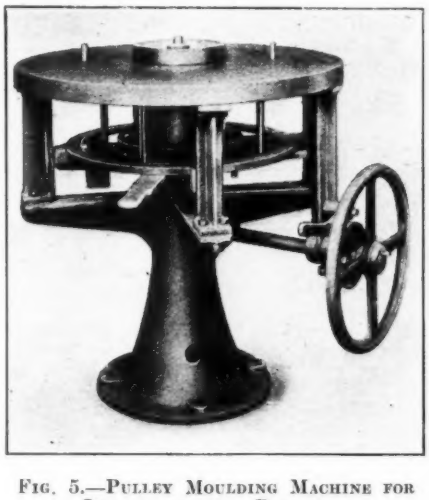

FIG. 5.—PULLEY MOULDING MACHINE FOR INTERCHANGEABLE PATTERNS.

the crosshead support, which forms part of the machine; the outer stripping ring and the inner plate are then secured to the table, the pulley-arm pattern being mounted on the inner plate.

The stripping cross-shaped supports of the machine may be lowered to such a position that the upper edge of the rim of the pattern is on a level with the table; it may also be raised as high as the half width of the pulley or the lift of the machine permits. Upon this machine it is possible to mould, in two-part flasks, pulleys with double arms without the use of core boxes.

The telescopic machine is built upon the same principle, but differs therefrom in that, within limits corresponding to the size of the machine, a number (up to 21) of rim patterns are arranged telescopically one within the other.

When it is required to mould a pulley of a certain diameter, all that has to be done is to set a pointer on a scale, when the desired rim pattern can be raised above the surface of the table by turning a hand wheel; the pulley-arm pattern is then inserted, and the machine is ready for working. As the different rim patterns in their lowest position form a level table, no special stripping rings are necessary. For special purposes the Pull-Through machines are made of the travelling type. Our illustration shows a machine designed on this principle for moulding cast-iron pipes, columns, or other long objects with straight sides. This machine is provided with a closed, dust-tight, box-shaped casing, within which the mechanism is enclosed. The flasks are rammed by hand, after which, by turning the hand lever, the pattern is stripped.

The Badische Machinenfabrik is represented in Great Britain and the Dominions by Messrs. S. Ingrams & Company, of 283, Finsbury Pavement House, Moorgate, London, E.C.2.

Death of Judge Gary.

Mr. Elbert H. Gary, the chairman of the United States Steel Corporation, died in New York last Monday at the age of 80. He was a past president of the American Iron and Steel Institute. He created the Steel Corporation, a combine with a thousand million dollar capital. When America entered the war he became chairman of the Steel Committee of the Council of National Defence, and for this work he was the receipient of many foreign decorations.

International Foundry Conference in Paris.

The following is an outline of the provisional programme for the ladies in connection with the International Foundry Conference.

Wednesday, September 7th.—Tour of Paris by automobile. Meet at 2 p.m., Boulevard des Italiens, corner of Rue du Helder. Return at 7 p.m. Tea at 5 p.m. at Chez Laurent, Avenue Gabriel.

Thursday, September 8th.—Meet at Place du Chatelet, near Theatre du Chatelet. Visit Conciergerie, Palace of Justice, Sainte Chapelle, Church of Notre Dame, Tuileries Gardens; visit Louvre. Tea at 5 p.m. at Galeries Lafayette or The Printemps.

Friday, September 9th.—Meet at 2.30 p.m. at Porte-Maillot. Visit to Malmaison (the house of Napoleon). Tea in one of the neighbouring cafes. Return by tramway at 6 p.m.

Saturday, September 10th.—Meet at 2.30 p.m., Esplanade des Invalides. Visit Chapel and Tomb of Napoleon. Walk along Champ de Mars to Trocadero. Tea at 5 p.m. on the terrace of the Trocadero. Return by underground railway.

Members who intend to take part in the Conference are requested to inform the General Secretary of their intention as soon as possible, and they are also urged to complete their booking arrangements with Messrs. Thos. Cook and Son at once.

Italian Foundryman Receives French Decoration.

Sig. Ing.-Com. Carlo Vansetti, the chairman of the Milan Steel Foundry Company, has had conferred upon him by the French Government the distinction of being a Chevalier of the Order of the Legion of Honour. Mr. Vansetti has already been honoured by his own Government by the award "Commander of the Order of the Crown," and by the British Government by the C.B.E.

British Exchange Paper Withdrawn.

Mr. J. T. Goodwin, the President of the Institution of British Foundrymen, has found it impossible, on account of pressure of business, to prepare his Paper on "The Use of Granulated Iron in the Foundry," in time for presentation to the French Foundry Congress.

Foundry Purchasing—X.

BY ERIC N. SIMONS.

It must not be assumed from the rigid analysis of the functions of the foundry buying office given in the preceding article that, because a requisition for, say, tools, received from the moulding shop comes under the heading of "works materials" and is dealt with by the assistant responsible for this class of purchases, a requisition from the foreign department for similar tools for "re-sale," dealt with by the assistant responsible for re-sale materials, must be kept entirely separate. This would be to defeat the whole object of centralised buying. If any advantage is to be gained by lumping both requisitions together on one official order, it is the buyer's duty to gain it. The task of the separate assistant is to see that ultimately, when the goods have been obtained and delivered to the respective consumers, each is debited with his proper proportion of the cost. In a later article on purchasing methods, systems of classification and handling will be fully discussed.

Similarly, the reader must not interpret too literally the statement that the assistants concerned carry out personally the detailed work outlined in the preceding article. Because it is there declared that each assistant is responsible for the inspection and testing of his particular class of goods on arrival, it should not be assumed that this means he must actually test and inspect materials himself. Obviously, he might not be competent to do so. A purchasing clerk would not be the right man to inspect, for example, a consignment of leather belting; nor would he have the technical knowledge requisite to enable him to test a piece of nickel-chrome steel required for a special purpose. All that is implied is that he, as the official in charge of the work connected with the buying and ordering of a certain class of purchases, must take upon himself the responsibility for seeing that the inspection and testing are carried out by someone; himself, if competent; if not, the right person. In the same way, when it is suggested that one part of the assistant's work consists of visiting the suppliers' works to indicate the need for delivery, this means that he must see that someone, either himself, the buyer, the firm's travelling representative for the district concerned, or someone else, does visit the supplying firm, if circumstances make it essential.

Before passing on to discuss the personnel of the buying department as individuals, something needs to be said concerning the importance of carefully checking, receiving, and storing materials. It matters very much to the ordering firm whether or not goods are delivered in accordance with the terms of the order; *i.e.*, are correct in quantity, quality, dimension and weight. If any errors are discovered, surplus quantities, inferior or wrongly-made goods, undersized or oversized articles, must be promptly returned, carriage forward, and the accounting and traffic departments notified of these actions. (Irrecoverable losses can occur through the failure of storekeeper or purchasing department to keep railway charges in view, because these charges often come through after other details have been settled.) By careful receiving, testing and storing, the ordering firm is able to assure itself that it obtains value for every penny spent; that there is a minimum of wastage through deterioration and bad stock-keeping; and a means of obtaining accurate cost figures for the various producing departments.

In any efficient storing system one feature will be the maintenance in perfect order of a full and ever up-to-date stock record, showing at a glance the condition of the stocks at any given moment; and an equally full and current record of every delivery of materials into stock and issuing of materials to consuming departments from stock. The importance of the first feature, the complete stock record, is that it enables the storekeeper or the buyer to tell at a glance from day to day when stocks of important materials are approaching either the maximum quantity desirable or the minimum quantity expedient. The fixing of these limits is a necessary and an important part of the buyer's personal functions. Without them he will never be certain when he is buying more than is expedient or when he is cutting stocks so fine as seriously to threaten the productivity or prosperity of his firm. Their fixing will, of course, be based upon his buying records over previous years, without which they would be merely arbitrary limits, with no practical justification. But since it cannot be expected that the buyer shall, every day of his business life, go conscientiously through the stock record—which is his storekeeper's business—the storekeeper must have these limits to enable him to know when the buyer should be notified that they are being approached, in one direction or the other.

Staffing the Buying Office.

In engaging or training assistants for the buying office, it must be remembered that the work is of a responsible and intricate character, calling for intelligence, initiative, and, above all, care. There is a tendency on the part of some firms to dump any misfit they have about into the buying office, in the belief that there he will find a soft, comfortable billet. This is as absurd as founding the department itself on a policy of buying the cheapest goods irrespective of quality and performance. In few offices are blunders more costly than in the purchasing department. A mistake on an order, even in the simple work of copying from a requisition, may go undetected and involve the purchaser in needless expense. Low-salaried, half-educated assistants are useless. At least four good, intelligent and careful men or women are needed, subject to the remarks as to the size of the department laid down in the preceding articles. It is better to have four men with every minute of their working day occupied than five with big gaps of idleness. More work is invariably obtained from four kept employed than from five with leisure. At the same time, it must be remembered that absences, either on account of annual holidays or through illness, will be unavoidable in the course of a year. If the assistants are all over-driven, the absence of one for any period is likely to throw the work of the department wholly out of gear. The work is continuous, and far too important to the well-being of the firm to be scamped or neglected. The natural conclusion is, therefore, that either a general handy man must be a permanent member of the department, one able to carry on the activities of a sick or absent assistant, or each assistant must be able to take on a portion of another's work during his absence, sharing with the others. In some buying departments, the "handy man" is employed normally as a correspondence clerk or typist of superior abilities, but is able to do the routine work of a higher official for a short period if necessary. When this clerk is engaged in filling the shoes of an absent assistant, his or her own place is taken by a temporary typist. In this way the staff is kept at an economic level, without being stranded in an emergency.

There is considerable advantage in having each assistant understand the work of his colleagues, so that in case of need he can competently execute any part of the work of any of them. This gives him a broader outlook on the department and its activities, and prevents the functional jealousies common in offices where each man keeps to one task throughout his employment. In one buying department the excellent system is adopted of grading the four classes of buying in order of their intricacy (which, of course, may vary with different foundries). The oldest and best assistant is given the most intricate or highest grade after he has worked his way through the others. In this way, by the time a man comes to do the work of Grade I purchases, he has already learnt all there is to learn about Grades II, III and IV, and can switch over to them at any time. Similarly, the man engaged on Grade II purchases can do Grade III and IV work; and so it goes on. When the Grade I assistant is himself away, his work is usually carried on by the buyer in person, unless he entrusts it to the Grade II man for the sake of giving the latter experience, acting himself in the capacity of adviser and tutor.

Progress in the Production of High Duty Cast Iron.*

By Professor E. Piwowarsky.

Great progress has been made during the last few years in Germany in the development of grey cast iron, due to the greater emphasis put upon metallurgy in the foundry industry during recent years.

Existing Specifications.

It will be noted from the specifications for strength as given in Table I (these corresponding to stricter requirements of more recent purchasing specifications) that grades of cast iron are already regarded as "high-duty," which show a tensile strength of from 11.5 tons to 16.5 tons per sq. in. and modulus of rupture of 17.8 tons to 22.2 tons per sq. in. But these figures represent values which every well-managed foundry can attain without difficulty in the regular run of work.

While some of the prominent foundries were already able one or two decades ago to produce high-test cast iron with a transverse strength of 28.5 tons per sq. in.—material which later microscopical examination showed to be of a purely pearlitic structure; and while, moreover, P. Goerens had already shown in 1906 that if cast iron of greatest strength were wanted, a pearlitic structure should be aimed for; yet in most cases the foundry manager placed his confidence more particularly in the skill of his practically trained foreman, rather than upon the results of a greater emphasis laid upon metallurgical scientific control.

Those foundries, however, in which the existing status of metallurgical science has been properly utilised, and who consequently could produce high-grade castings, did not see the immediate necessity for publishing their operating methods and thus deprive themselves of an advantage.

It was only when the papers of K. Sipp and A. Diefenthaler, in which the word "pearlitic" as applied to cast iron was coined, were published, did there appear a flood of literature on the subject, both from practical and scientific aspects, but mainly in reaction against a too liberal interpretation of the patents on pearlitic cast iron, and to confine them to their proper basic idea—namely, the systematic pre-heating of the mould in conjunction with a correspondingly suitable mixture—and to show that there are other ways and means of producing high-test cast iron with a preponderance of pearlitic structure.

The publication of Maurer's cast-iron diagram, and of the high figures of strength for grey cast iron reached by Krupp; the publications of K. Emmel on his high-duty, low total-carbon cupola iron (Thyssen-Emmel); the graphic interpretation—with resemblance to Maurer's cast-iron diagram—of the relations between thickness of section on the one hand and silicon and carbon percentages on the other by Greiner and Klingenstein; all these and many other similar publications have shown that suitable operating methods were already in existence which allowed structural control of the metal matrix, and that with a pearlitic matrix structure alone the high-duty characteristics of grey cast iron were by no means guaranteed. It was generally recognised that the Lanz pre-heated mould method was the ideal solution of the special problem of particularly complicated castings involving greater resistance to growth phenomena under higher temperature ranges, as also the high-test characteristics of that material. The novelty of the method was questioned but in few instances.

The development of lines of better structural control of the metallic matrix could really only go either by way of lowering silicon, or lowering the total carbon. They are fundamentally partially dependent upon the formerly prevalent uncertainty of structural control in ordinary, normally constituted grades of iron. Whence came this uncertainty?

Causes of Uncertainty of Facts.

It is well known that a high silicon percentage, as well as a high total-carbon, favour the rapidity of carbide decomposition, and only recently this well-known fact was proved quantitatively by Oberhoffer and Piwowarsky in connection with dilatometric investigations.

A high silicon, as well as a high carbon content, accelerate the disintegration of cementite just below the melting point (region of rapid rates of disintegration), *i.e.*, the iron becomes effectively graphitised. Graphite and temper-carbon, however, dissolve comparatively slowly in iron, and (at least in the early stages) partially as elementary carbon. Both the above conditions, however, at low degrees of superheat and too rapid setting of the metal, favour a graphitised product (commencement of graphite crystallisation, cessation of phenomena attending a retardation of solidification below freezing temperatures). With increasing degrees of superheat, however, the particles of undissolved graphite present in the melt disappear more and more, increasing quantities of carbide molecules are probably formed in the melt, and the iron sets with constantly whiter fracture; as in the region of rapid rates of disintegration of carbide, directly after setting the necessary crystallisation tendency is diminished. This is why it is possible to succeed in getting iron of the same composition and under equal rates of cooling to set with either a grey or a white fracture, as desired. The above discussed fact, taken, however, in connection with the formerly prevailing considerably lower melting and pouring temperatures, is undoubtedly the principal reason for the then existing inability to obtain reliable results; as also the observation that conflicting opinions existed until recently concerning the effect of the pouring temperature upon the quality and hardness of the product.

Hailstone,* as well as Honda and Murakami, found a distinct percentage reduction in graphite with rising pouring temperatures up to about 1,425 deg. C., while Northcott,† for instance,

TABLE I.—*Synopsis of Specifications for Strengths of High Duty Cast Iron.*

Source of Specifications.	Tensile strength, tons per square inch.	Modulus of rupture, tons per square inch.	Deflection in inches.
Bureau Veritas, 1914	11.5	—	—
German Navy, 1913	—	21.5	0.39
German State Railways	11.4 to 16.5	—	—
German Association for Testing Materials and Cast Iron Pipe Manufacturers' Society	—	21.5	0.39
German Lloyd	—	21.5	0.39
Holland, 1911	11.4 to 26.5	(18.4)	—
Roumanian State Railways	10.2 to 11.4	—	—
Swiss Federal Railways	11.4	—	—
American Society for Testing Materials ..	12.4	(34.0)	0.12
		(21.7)	0.09

Figures given in parentheses have been calculated from minimum transverse requirements. (The rupture modulus and deflection figures given are probably calculated from the German standard test bar 1.2 ins. diameter, 25.6 ins. long, broken on supports 23.6 ins. apart.—ED.)

* An Emended Abstract of a Paper read before the American Foundrymen's Association, made by the B.C.I.R.A. Staff.

* Carnegie Scholarship Memoirs, C5 (1913). P. 51.
† FOUNDRY TRADE JOURNAL, 29 (1924). P. 515.

found the reverse to occur with the range of 1,220 to 1,410 deg. C. The relation between chemical composition and structural development is naturally affected—on occasion very far-reachingly—by the conditions of operation, mixture-making, and temperature. As a consequence possibly many of the more recently developed relationship deductions may not have unlimited validity. This may extend possibly even to Maurer's as well as the Greiner-Klingenstein diagram.

Two Solutions Offered.

There were two ways of coming over the specified difficulty, ways which—often unconsciously, perhaps, in structural-scientific relation—were, nevertheless, the outcome of good practical observation. The first way was the reduction of the rate of carbide disintegration during the melting operation by the use of irons low in silicon in the mixture. In this manner of proceeding, however, the rate of cooling must be artificially retarded—*i.e.*, the elimination of a part of the silicon in its action upon the rate of disintegration of the iron carbide during the setting of the iron must be compensated for by the pre-heating of the moulds to differently high degrees. There is an advantage to this method, however, in that a cast iron is produced which exhibits an increased resistance to "growing" at high temperatures. Lanz has systematically followed this direction, and it has been brought to its full fruition by the investigations of K. Sipp and A. Diefenthaler.

The same objectives, by the second method, were attained by reducing the total carbon and thus bringing about a lower rate of iron carbide disintegration before actual fusion. Iron carbide is much more stable when in dilute solution, and the possibility of temper-carbon formation during the melting process is restrained. The molten solution will, accordingly, be homogenised more rapidly here also, and existing graphite and temper-carbon particles be dissolved more quickly, and the structural dependence of the solidified matrix of the grey cast iron upon the mixture will show more dependable correlations in accuracy of results and smaller sensitiveness to changes in section.

This method, evidently the basis of the Thyssen-Emmel process, has the advantage that in consequence of the higher silicon content it is not necessary to retard the rate of cooling artificially, and it is possible to make use of mixtures suited to rates of cooling existing under ordinary room temperatures in foundries. Because of the reduction in the absolute graphite content, there also results an appreciable improvement in the physical properties of the resulting cast iron. K. Emmel has succeeded in completely overcoming all the difficulties arising in producing a low total-carbon cast iron of sufficient temperature and highest quality in the cupola under normal operation, and pouring into successful work.

Studying the above-described methods in conjunction with the state of the art of founding as it existed five or ten years ago, it is seen that their origin came, on the one hand, from an uncomfortable lack of precision in getting desired results in the production of grey iron castings; and on the other, that it was most urgent, in view of the increasing competition in the world market and the sharp rivalry of the steel casting, to discover qualities in cast iron which calm reflection indicate as still latent therein.

Low Melting Temperatures versus Superheating.

From a strictly metallurgical standpoint, however, it is unquestionably true that the principal cause of imperfections met with lies in the melting and pouring temperatures used, which are much too low and consequently impair the homogeneity of the casts, are insufficient for a complete solution of graphite, and cause the structure of cast iron to become the toy of the most varied operating conditions.

The investigations of the author, which proved experimentally that the degree of superheating temperatures attained by the molten metal determines the percentage and fineness of the graphite in it, thus represent a distinct advance. It was even proved that variable degrees of high superheat in the production of the hard casting for "malleable" had a distinct effect on the subsequent annealing results. As it could be proved—by laboratory as well as industrial tests—that an extraordinary degree of quality could be attained when operating with high degrees of superheat, and that there was developed a graphite formation which was very fine, for the most part in eutectic or temper-carbon form, a patent was applied for in Germany to cover the systematic abnormal superheating of cast iron in the molten state. (This patent application calls for an added 30 to 180 deg. C. to a previously mentioned critical temperature, which will be further discussed later on, and which places the temperature range of operations into a region corresponding to 1,500 to 1,700 deg. C.)

Theories Developed by Science of Crystallisation.

Regarded from the standpoint of the science of crystallisation the following may be added to the above:—It is probably generally well known at the present time that the setting of high total-carbon irons within the temperature ranges of increasing retardation of solidification below freezing temperatures, takes place with an increasing rate of temperature drop. That is, the temperature of freezing decreases increasingly into the range of rapid spontaneous formation of cementite crystals in the interior. If the chemical composition assures a sufficiently rapid disintegration of the carbide, a breaking up of the metastable eutectic with formation of fine eutectic graphite will take place even under conditions of rapid cooling. This is shown in the chilled cast iron of Schüz, which contains 3.00 to 3.50 per cent. silicon. Otherwise the iron would solidify white in fracture. As the author had been able to demonstrate—by laboratory tests and practical works' studies—that an increasingly marked subdivision of the graphite also takes place, under conditions of equal and even very slow rates of cooling, as the degree of superheat increases, he suspected that dissociation phenomena (of the iron carbide), or changed gas solubility, must be the real reason for graphite subdivision—regardless of the various explanatory hypotheses on the destruction of graphite nuclei. He could actually prove this supposition by the following experiment:—

Metal Poured Into a Mould With Variously Heated Sections.

Three heats of iron of identical material, and approximating the same composition (TC, 3.00 per cent.; Si, 2.20; Mn, 0.45; and P, 0.02 per cent.; with traces of S) were made in an experimental crucible furnace. The first melt was superheated to 1,260 deg. C., the second to 1,425 deg. C., and the third up to 1,600 deg. C. All melts were allowed to remain at their respective maximum temperatures for 10 minutes and each promptly poured into a test bar 1.20 ins. dia. and about 20 ins. long. The mould was specially devised to provide means for obtaining wide ranges of the cooling rate, and consisted of five parts of equal length; a chill section, a green-sand section, a dry-sand section; and a section heated to 500 deg. C., in the order named, the chill at the bottom; on top of these was a pouring basin large enough to serve as a sink-head. The pre-heating of the top section was brought about by the insertion of a Ni-chrome electric heating coil while ramming up. A thermo-couple was inserted in the middle of each mould section. Table II gives the eutectic arrest-temperatures.

Conclusions Drawn From Investigation of Heated Mould Sections.

It will be seen from the results obtained that not only the rate of cooling (vertical figures), but also the degree of superheat (horizontal figures) exert an equally directed influence upon the position of the eutectic temperature. In view of the retarded rate of cooling due to increasing pouring temperatures, as shown in the horizontal divisions, one would rather have expected a raising of the eutectic arrest-temperature (in correlation with the rates of cooling shown in the vertical division). Yet, beyond the equalisation of the effect of this increasing retardation, there appeared on higher degrees of superheat, quite

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contrariwise, a rapidly-increasing retardation of solidification below the freezing points of the melts. This observation consequently furnishes the explanation, in figures, for the mechanism of the graphite size as the degree of superheat increases.

TABLE II.—*Influence of Rate of Cooling and of Superheating upon the Eutectic Freezing Temperature.*

Kind of mould.	Pouring temperatures in Deg.C. Heat No. 1. 1,260	Heat No. 2. 1,425	Heat No. 3. 1,600
	Eutectic temperature, deg. C.		
Sand mould, heated to 500 deg. C. ..	1,185	1,177	—
Dry sand mould ..	1,152	1,147	1,130
Green sand mould	1,136	1,127	1,102
Chill mould ..	—	—	1,013

It was noticed from micro structures of the vertical divisions that as the rate of cooling is retarded with increasing temperatures of superheat the increasing coarsening of the graphite crystals was plainly impeded. It follows, therefore, that the molten iron, superheated to the abnormal point of 1,600 deg. C., becomes much less sensitive, so far as its graphite formation is concerned, to changes in the rate of cooling, or, what is the same thing, it is less dependent upon the thickness of section, retaining the finely-divided graphitic structure more readily even with slow rates of cooling (heavy sections). The ultimate result of this systematic subdivision of the graphite, by reason of abnormal superheating, is a *systematic retardation of solidification below freezing temperatures on the part of the melt without increasing the rate of cooling.* The application of abnormal superheating temperatures has, therefore, accomplished what E. Schüz obtained with his chill cast iron of about 3.5 per cent. total carbon, namely, the formation of graphite in a finely-divided eutectic state. The method of applying abnormal superheat, therefore, has the advantage of being applicable to all cooling-rate conditions, for all irons, irrespective of their composition.

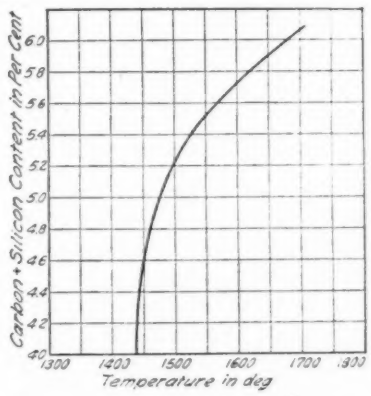


FIG. 1.—HEATING CURVE TO OBTAIN EUTECTIC STRUCTURE OF THE GRAPHITE.

Relation Between Chemical Composition and Superheating.

The relations between chemical composition and superheating were recently investigated more thoroughly by means of systematic tests made under abnormal superheatings at the Esslingen works in the Wüst oil-fired furnace. The specific minimum temperatures were obtained which must be reached for given silicon and total carbon content of the irons in question, in order that carbon may be precipitated in its eutectic form (Fig. 1).

Strengths up to 26.6 tons per sq. in. tensile, and a modulus of rupture of 46 tons per sq. in., have been attained without subsequent heat treatment by operating under the superheating method in question in the production of high-test cast iron. Strengths up to 23 tons per sq. in. tensile could be obtained even from the cupola, with irons running about 0.40 per cent. of phosphorus, extra precautions, however, being taken to attain very high temperatures when so doing.

Relation Between Melting Temperatures, Superheating and Contraction.

The relation between melting operation and contraction phenomena will be illustrated in what follows, for, as will be proved later on, there actually is such a relation, and it is of the greatest importance in connection with the internal stresses and volume constancy of high-test cast iron.

Since higher pouring temperatures are used more generally to-day, a better degree of temperature equalisation throughout the casting is made possible. As the temperature differences between surface and interior of the casting are lessened, contraction effects are also reduced. This is also in accord with the fundamental conception of "internal shrinkage." It was possible to furnish qualitative proof of the above by pouring off a series of rather large grids.

TABLE III.—*Expansion at Moment of Solidification Depending upon Preceding Superheating, the Pouring Temperature being the same in each Case.*

Heat No.	T.C.%	Gr.%	Si.%	Superheated to deg.C.	Poured at deg. C.	Actual contraction %	Expansion.* %	Total contraction.
1	3.26	3.02	2.24	1,300	1,250	0.385	0.352	0.737
2	3.30	2.51	2.18	1,450	1,250	0.320	0.529	0.849
3	3.23	1.99	2.24	1,600	1,250	0.753	0.240	0.993
4	3.52	3.08	1.74	1,300	1,250	0.497	0.192	0.689
5	3.36	1.71	1.54	1,450	1,250	0.833	0.448	1.281
6	3.56	2.22	1.74	1,600	1,250	0.432	0.417	0.849
7	3.28	1.51	0.82	1,300	1,250	0.933	0.256	1.189
8	3.02	1.23	0.98	1,450	1,250	1.008	0.481	1.489
9	3.24	1.16	0.92	1,600	1,250	1.300	0.096	1.396

* On solidification.

The greater degree of contraction while in the fluid state, where higher pouring temperatures are used, and the consequent stronger tendency on the part of such molten metal to feed up well should not, however, be confounded with the above described contraction process occurring during the change in the state of the aggregates. Experimental attempts made to obtain numerical values of the contraction occurring in three series of irons with decreasing silicon content, each of equal temperature, with increasing degrees of superheat—the measurements being made with Wüst's contraction apparatus as improved by Ebbefeld and Bardenheuer—unfortunately did not result in showing a clear-cut relationship between the true contraction and increasing superheat. The influence of an increasing silicon content upon the diminution of the true contraction could be plainly recognised here. The actual contractions were as is shown in Table III, wherein the following data is pertinent:—

Series I (Heats 1 to 3).—Silicon 2.00 per cent.—Average contraction 0.486 per cent.

Series II (Heats 4 to 6).—Silicon 1.60 per cent.—Average contraction 0.587 per cent.

Series III (Heats 7 to 9).—Silicon 0.95 per cent.—Average contraction 1.08 per cent.

These tests, on the other hand, brought out another correlation, which is at least as important. The *expansion during the moment of solidification* was always smaller in the case of the lowest and highest degrees of superheating than with the intermediate ones, in which—or directly below their range—there lie the usual normal maximum treatment and pouring temperatures of cast iron in daily practice. One might be tempted to infer from this a preference for the melting and pouring requirements in use at the present time, since the augmented expansion during the moment of set is able to reduce the amount of true contraction. Were this expansion phenomenon during

the moment of solidification the result of a carbide disintegration only, the author would consider such a conclusion correct. However, it is noted from the contraction measurements of Wüst and Shitzkowski that pure iron-carbon alloys below 1.7 per cent. in carbon content—which consequently solidify without the formation of Ledeburite—also show expansion during the moment of solidification. The author is inclined, therefore, not to discard the views of Ebbefeld and Bardenheuer, who hold that the separation of the occluded gases during the transition from the fluid to the solid aggregates should be made responsible for the expansion phenomenon described. These two investigators have shown, among other things, that in increasingly rapid melting procedure for cast iron, in a vacuum, the expansion during the moment otherwise observable when melting in the atmosphere can be made gradually to disappear. Ebbefeld and Bardenheuer, however, conducted their researches under melting temperature conditions but little above 1,300 deg. C. The expansion during the moment of solidification would seem to justify the conclusion that as the temperatures increase above a given critical range the evolution of gases in cast iron during the moment of solidification decreases again. This interpretation seems to be verified by results from tests made with newly-devised apparatus—though the tests are unfortunately still uncompleted.

Should these observations be further substantiated, the expansion referred to above during the moment of solidification would prove to be not only of little use, but actually harmful; for the extent of this expansion could then be taken as a measure of the decrease in density consequent to the evolved gases causing porosity in the material. As a matter of fact, some very careful determinations of density conducted later have verified this assumption.

For a long time the author has vainly sought for an explanation of his numerous observations to the effect that only a very high degree of superheat—not current in practice heretofore—produces an optimum of physical properties in cast iron; even though medium high ranges of superheat already produce a marked increase in fineness on the part of the graphite. It is thought, therefore, *that the greater density of abnormally superheated cast iron, in conjunction with the distribution of fine graphite, explains the markedly beneficial effect of this melting procedure.* This would also partially explain his observation that to obtain the optimum of physical properties the degree of required superheat will change with the chemical composition. For instance, as the silicon content rises the degree of superheat given the metal may be lowered. Silicon in iron, namely, lessens the possibility of coexistence of an easily-reduced and gas-producing ferrous oxide. It also lessens the solubility of hydrogen in iron, as indicated by Troost and Hautefeulle in 1876. In fact, Ebbefeld and Bardenheuer found a diminution in expansion at the moment of solidification, in their tests, when the silicon increased, as shown in Table IV. All of which would bring us to the following conception of the occurrences in question.

Table IV.—*Influence of Percentage of Silicon upon Contraction (Ebbefeld and Bardenheuer).*

Heat No.	T.C. %	Gr. %	Si. %	Total contraction. %	Expansion*. %	Pouring temperature, deg. C.
69	3.40	2.15	1.26	1.341	0.169	1,305
86	3.25	2.30	2.00	1.220	0.057	1,232
85	3.23	2.44	3.24	1.163	0.054	1,212
87	3.15	2.44	3.56	1.011	0.024	1,232

* On solidification.

Conclusions Drawn From Superheating Experiments.

(1) The increasing carbide formation in cast iron when solid, *always* obtained with increasing degrees of superheat given the metal when molten, would be explained by the disappearance of mechanically disseminated graphite particles, as well as an increase in the carbide molecules in the melt. (Korber, Hanemann, Sauerwald.)

(2) The diminution in size of the graphite particles already becoming more apparent as the medium ranges of superheat are reached, is brought about through the gradual decrease of the critical eutectic temperature, since solidification takes place increasingly in the regions of spontaneous crystallisation. The disappearance of the graphite nuclei *overbalances* in its influence the opposing tendency of the gases—in variable volume in the solidifying iron—to promote solidification below normal freezing temperatures together with an increased disintegration of carbide. Also (in case of pouring hotter) the influence of a retardation in the rate of solidification results from a more effective pre-heating of the mould by reason of the increased pouring temperature.

(3) The increasing rate of subdivision of the graphite particles observed when superheating to a higher degree could then be attributed to the increasing tendency towards solidification at temperature ranges considerably below normal freezing, and increasingly growing spontaneous crystallisation—as a consequence of the gradual diminution of evolved gases from the melt. The proportion of graphite increase in the solid phase to the total carbon content (critical temperatures, inverse curves) might be explained as—

(*a*) By the faster and stronger development of sensible heat at increasing solidifying tendencies below normal freezing points; and the annealing effect of this upon the carbide;

(*b*) By the increasing formation of molecules of the elementary carbon arrangement in the melt (dissociation) on passing the critical temperature;

(*c*) In the case of pouring at these higher temperatures into intensively preheated moulds, by the only now fully effective retardation of the rate of cooling within or just below the point of solidification.

Jolting of the Molten Iron.

The beneficial effect of the graphite subdivision and reduced gas evolution upon the quality of cast iron when subjected to abnormally high temperatures could also be expected, from the foregoing discussion, had the molten metal been treated while under a vacuum at somewhat lower temperatures (1,400 to 1,500 deg. C.); or had it been "jolted" with suitable mechanical contrivances. K. Irresberger was able to obtain very good physical properties when jolting his molten cupola metal in a forehearth equipped with a motor-operated eccentric lifting and dropping base. In order to effect the removal of gases and slag still better, the author has proposed that the forehearth or mixing-ladle be given a rotating motion, so that the lighter non-metallic inclusions may be forced inward by centrifugal action and thus be given opportunity to rise and enter the slag.

Theories Based on Formation of Graphite Above Critical Temperature.

So far as the increasing tendency on the part of the iron to precipitate graphite in passing the critical temperature is concerned, an increased tendency toward graphitisation, as compared with the medium ranges of superheat, must be deduced even where the graphite percentages of the abnormally heated metal remain constant. This, because the influence of the evolved gases favouring the disintegration of carbide (Maurer, Honda and Murakami) during the moment of solidification, is gradually diminished and must be compensated. Attention has been called from various sources to the fact that his conception of the co-existence of two varieties of molecules in the molten iron—each variety in balance with its products of dissociation—is based upon too few observed facts, or may even be based upon erroneous data. It was pointed out that if the author were correct in his assumptions, that Sauerwald should also have found an inversion of the specific volume when making his density determinations of molten iron. These claims do not seem to be fully justified—for the specific volumes of white and grey pig irons do not vary from each other more than 1 per cent., according to the results obtained by F. Sauerwald and J. Wecker. (From this there can incidentally be deduced that the greater part of carbon in grey iron is dissolved in it in carbide form, for a

transformation of but 0.6 per cent. combined carbon, equalling 9 per cent. Fe_3C, into elementary carbon and iron is already coexistent with an expansion of one per cent. If, now, the mass of molecules available for this transformation is smaller than would correspond to 0.6 per cent. carbon, the molecular transformation will not be noticeable when measured by apparatus sensitive to changes of plus and minus 1 per cent. In the meantime, however, Wedemeyer, conducting tests in a coal-fired air furnace on an industrial scale, confirmed the author's observations.

Wedemeyer found that the carbide content of castings was dependent in the same sense upon the height reached by the temperature of superheating as well as its duration, as the author had announced it in his first publication. Wedemeyer also verified the decreasing quantitative controlling ability as the silicon content rose, for, in making rolls with 0.45 to 0.60 per cent. silicon, the differences in carbide content came out greater by reason of the conduct of the melting process than where hematite ore pig-iron of 1.25 to 1.75 per cent. silicon had been used.

Hypothetical Explanation.

Furthermore, the author has based his hypothetical explanation of the phenomena in question upon the following reaction:—

$$C + 3Fe = Fe_3C + W.E.$$

(W.E. is positve above the critical temperature; W.E. is negative below the critical temperature; W.E. $\doteq \pm 0$ at the critical temperature.) This hypothetical explanation the author now holds—but only until it may have become possible to obtain a direct proof of what actually happens. Besides determining the specific volumes, it may become necessary to obtain the viscosity (complicated molecular formations would be accompanied by high degrees of viscosity—for instance, in the case of a carbide as against an elementary arrangement), also to get the electrical conductivity. The author considers that Korber's theory, holding the superimposition of two diametrically opposed processes—namely, the increasing solution of mechanically mixed graphite particles and the increasing dissociation of molecular iron carbide—to be active in promoting inverted curves: is not so unjustified. Furthermore, the gas phase is evidently also quite effective, for when he conducted melts in vacuum the carbide reversal rarely occurred. At any rate Haneman has again been able to verify—as the result of his microscopical examination—that for moderate ranges of superheat, the crystallisation brought about by nuclei of undissolved carbon has a potent effect upon the size of the graphite particles, in consequence of the retardation of the solidification process in considerably extended regions below the normal freezing point. From numerous observations and investigations the author has concluded that the use of grey-fractured pig-iron in the foundry industry retards the complete solution of the graphite when melting under conditions of moderate ranges of superheat.

Process for Producing High-Duty Cast Iron.

The author has, therefore, proposed a simple method for producing high-duty cast iron, in which all pig-irons—even those with high silicon content—are specified to the furnaces on purchase, to be machine cast; and, if possible, to be water-chilled in addition, irrespective of what they contain. If the melting process in cupola, air furnace, or electric furnace is carried through sufficiently rapid the carbide will nearly all remain intact and go into solution in the melt, and a result is obtained similar to that when the molten metal is given an extended superheating treatment. That is, there is less undissolved graphite remaining in the molten iron. Such iron will then solidify under conditions of greater spontaneous temperature drops below the freezing point.

Dissolved gases seem to act in the same manner as an undissolved carbon content, for whenever the author made vacuum melts he noted the formation of eutectic structure developments. It would, therefore, seem advantageous to subject very highly superheated molten iron to jolting or centrifuging processes.

Random Shots.

Close on the heels of the meeting recently held in London to promote Rationalisation in industry, to which attention has already been drawn in these columns, comes the announcement of an important conference on a very similar subject. This is the Third International Congress of Scientific Management, which will take place in Rome from September 5 to 8 next. It follows on similar meetings held in Prague in 1924 and Brussels in 1925, and it will be held under the patronage of the King of Italy and the Presidency of Signor Mussolini. Various questions will be dealt with, including such topics as maximum production, factory lay-outs, labour-saving devices, and time-studies. This movement may sound to the foundry world remote to the verge of unreality, but there is no doubt that as a movement it is capable of immense development, and it is most assuredly one that should be carefully watched.

* * *

Much space in the Press has recently been devoted to the very striking increase in the electrical industry's export trade. Before the war the electrical industry was very much in the position of the automobile industry here in the days when mechanically propelled vehicles had to be preceded by a man with a red flag. Every factor that makes for the stifling of a new industry was present, and every maker had to be spoon-fed from abroad. To-day Britain leads the way as an exporter of electrical goods.

* * *

The reasons for this striking advance are given under five headings—manufacturing efficiency, research, low selling prices, selling policy, and manufacturers' co-operation. By these means the country has apparently been able to monopolise the greater part of the increased demand due to the rapid advance of electrification in all sorts of fields throughout the world. The whole business shows a confidence in the future and the possibilities of the industry on the part of the electrical manufacturers which might well be emulated in other quarters. When will the founding industry as a whole learn the same lesson? The very presence in the Press of all this information about the electrical industry is in itself evidence of highly skilful publicity.

* * *

Entertainment is perhaps more important than accuracy to sporting journalists—or at least to those members of the fraternity who fill their space with news paragraphs of a personal character. Needless to say, we except the prophets whose life-work consists of spotting winners for other people to back. . . . . We recently noted with some amusement that a prominent and popular member of the Warwick cricket eleven was originally destined for music, and proved a great disappointment to his father by preferring cricket. In point of fact the gentleman in question started life as a moulder on the foundry floor. It would be illuminating to discover how many men there are, now celebrated in different fields, who, like him, were once practically and actively connected with the industry. One notable instance is Mr. Arthur Henderson, P.C., M.P., the former Cabinet Minister. Can readers supply any further names? There must be a great many. . . .

* * *

That metallurgy is an entirely new field for women's work has been suggested by a number of comments on a recent award to a distinguished woman metallurgist. As a matter of fact a number of women have entered the profession at different times, chiefly during the war, when such work became of immense importance just when new workers were most scarce; and although the post-war years have seen fewer recruits the lady in question has a considerable number of fellow workers. True, they have not all attained her eminence, but like her they had to break new ground, and a woman metallurgist can hardly now be regarded as a pioneer, since it must be some twelve years since they first appeared on the scene.

New Electrode Holder for Electric Furnaces.

Hitherto electric arc furnaces of the Héroult type, in which the current flows in circuit from electrode—slag—bath—slag, to the other electrode, are almost always provided with an electrode suspension, in which the electrode is held in an arm projecting at a right angle from an upright. The tipping moment caused by the weight of the electrode suspended from the end of the projecting arm, is compensated by the vertical guiding movement of the other limb of the angle by means of rollers running in a side column. This type of electrode guide is very practical and suitable for the vertical working position of the electrode.

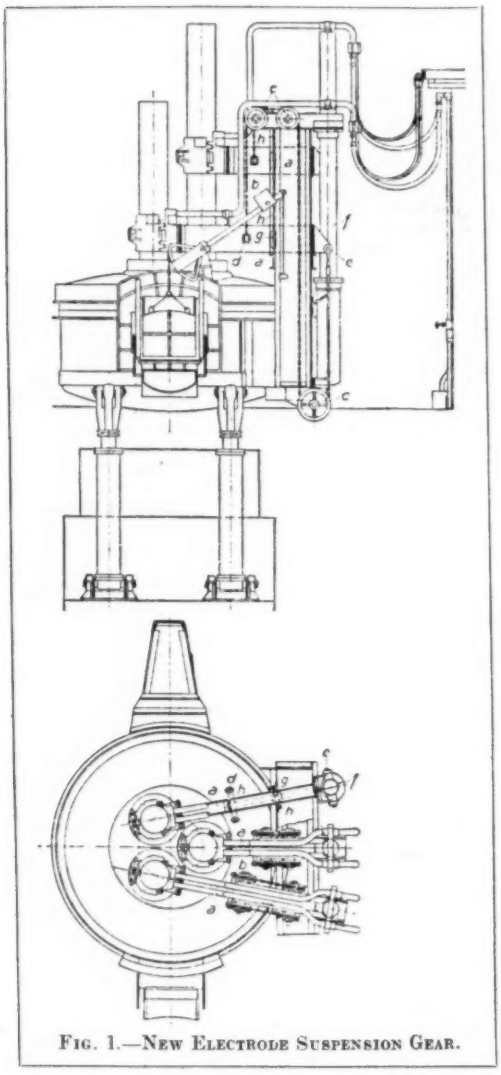


Fig. 1.—New Electrode Suspension Gear.

When, however, the furnace is tipped, other forces act vertically on the axis of the electrode, which place a still greater strain on the straight guiding movement, especially in the case of large furnaces with heavy electrodes. An electrode 1 ft. 8 in. dia. weighs about 3,000 lbs., so that a sufficiently rigid and accurate guide is not obtained. If such electrode guides are observed in practice, it will readily be noted that when tipping the furnace, the centre axis of the electrode is considerably displaced and the electrode rests on the cooling ring of the furnace cover. As a result thereof, the electrode is not carried by the arm, but on the contrary, the arm is carried by the electrode.

A new electrode suspension gear described in the "Demag News" claims to do away with this disadvantage. The carrying arm *a* (Fig. 1), consisting of a simple iron beam, is guided parallel by means of chains *b*, running over guide rollers *c*, the ends of which are attached to the carrying arm at *d* and *e*. The load moment of the carrying arm around the suspension point *d*, caused by the weight of the electrode, is compensated by the counter moment on the rear end of the arm at *e*. As this counter-pressure is produced by the arm pressure on the point of suspension *d* of the arm, stability, *i.e.*, complete counterbalancing of the weight, is obtained with electrodes of any desired weight. When operating the furnace in the vertical position of the electrodes, guides are not necessary. The forces vertical to the axis at the time of tipping the furnace are taken up by a round guide column *f*, to which the rear end of the arm is linked at *e*, and by a second guide, consisting of rollers *g* running between two rails *h*, in order to prevent the electrode carrier swinging out sideways. These guiding parts, which are situated a considerable distance apart, can be constructed without play and of such rigidity that, even in the largest furnaces, with correspondingly heavy electrodes, an easy and accurately working electrode guide is insured for all positions of the furnace. The guide columns *f* in the construction in Fig. 1 serve at the same time as lifting plungers for the hydraulic adjustment of the electrodes.

The Continental Steel Trust.

Due to the excess in production during the third quarter of the existence of the Continental Steel Trust, Germany will again have to pay a considerable amount into the equalisation fund, while the French works will again receive a considerable sum from this fund on account of not having reached the tonnage of their allotments. In the first half year of the activity of the Trust Germany had to pay $3,900,000 for excess output, while France received $470,000 as compensation from the fund for short production. In the meantime the penalty for excess production disposed of in the inland market has been reduced from $4 to $2 per ton, the rate of $4 still applying to German excess output sold in foreign markets, the percentage of which was fixed at 28 per cent. of their allotments. Owing to the reserve adopted by the Germans in the export trade it is estimated that they have scarcely reached this 28 per cent. in the third quarter, but as their excess output in this period still comes to about 830,000 tons, they will have to pay into the fund a sum of about $1,660,000. This is claimed to represent a burden of 1.75 marks per ton as compared with 2.61 and 1.61 marks respectively in the two preceding quarters. The definite figures for the French works are not yet available, but it is considered probable that the compensation to be paid to them will again mean a not inconsiderable reduction in their costs of production, which was put at 2.48 marks per ton in the first, and at 4.34 marks in the second quarter.

Under these circumstances it is not thought surprising that the German industry regards the formation of sale syndicates for the various rolled products as an urgent matter. The negotiations in this matter are only proceeding slowly, but an agreement has been finally reached as to the period to be taken as a basis for fixing the allotments. In this connection it is stated that the committee appointed in Luxemburg on June 9 to deal with the setting up of sale syndicates for semi-finished steel and shapes was to meet in Paris on August 5 for the first time and, should the occasion arise, also in Luxemburg at the end of September.

Notes from France.

At Conches, in the Eure Department of France, a new foundry is to be put into commission in the near future. It is to be known as S.A. Fabrication Moderne de Poterie, and the administrative offices are to be at Reims. This company has been organised by the well-known firm of Faure, of Revin, in the Ardennes, in collaboration with the foundry equipment firm of Baillot, of Saint Ouen.

The works of Usines Robert, rue Berthelot, Saint Dizier (Haute Marne), have been damaged by fire. Particularly has the foundry suffered, all the machinery being destroyed.

Mr. Ch. Kœhler has been elected Hon. Secretary of the Association Technique de Fonderie. Mr. Kœhler is managing director of the Société des Fonderies de Saint Ouen.

British Blast-Furnace and Cupola Practice.*

By J. E. Fletcher, M.I.Mech.E.

The slump in the iron and steel industries is responsible for the fact that there is comparatively little to record in the matter of British blast-furnace development during the past two years beyond the tendency to improve auxiliary plant. This tendency may be seen in the approach towards American methods in the direction of labour-saving machinery; the speeding up of output by means of more efficient charging gear and stove equipment; and the greater attention to gas cleaning and the disposal of slag. The closer study of international blast furnace technology is now resulting in a gradual application of the best forms of auxiliary plant, especially in connection with stove control, gas cleaning, and furnace charging. Perhaps the greatest hindrance to effective economic development is the awkward lay-out of many of the older and smaller plants, where, owing to the cramped position of the blast-furnace and stoves relative to the ore and fuel storage and distributing areas, the problem is difficult to solve. With this is frequently bound up the associated problem of transport of the raw materials, fuel, and the pig-iron and slag products.

When the shape of the furnace lining, as found by long experience, is the best for the average burden employed, the actual carbon (coke) consumption is practically constant within the working limits for each rate of driving. Hence the cost of fuel, flux and ore per ton of pig-iron produced, as delivered on rails at the plant, is often an approximately irreducible factor. The costs of transport, handling, charging, blowing, gas cleaning, etc., constituting what may be termed the auxiliary factor, vary considerably in different plants, according to the effectiveness or otherwise of the design and operating efficiency. It is this auxiliary factor which is in general need of much closer attention, the lack of which leads to poor and costly production. With the leaner and finer ores now so much used the mechanical handling of every portion of the furnace burden, the blast and water supply, and the final disposal of the furnace products, pig-iron, slag, and throat gases are engineering details requiring the most serious attention, apart from their metallurgical significance. The cost of such service is often the factor which determines the profit-earning capacity of a blast-furnace plant, and it is here where modern engineering methods can reduce the cost of pig-iron to a greater degree than is possible by attempts to save fuel, especially where the iron being made is of the higher qualities. In the smaller furnaces, where the auxiliary factor of cost is high, due to low mechanical efficiency, it is not infrequently found that the throat-gas energy is insufficient for the needs of the plant, extra fuel being necessary, either at the boilers or in the form of coal added with the coke to produce richer throat gases.

Fuel Economy within the Furnace.

If, as seems probable in the light of recent research, the best pig-irons for steel and wrought-iron making, and for foundry purposes, contain low carbon percentages, the tuyere and fusion-zone levels must be low, the fusion-zone temperature high, and the preheating and reduction zones as shallow as possible. The reduced iron would then pick up the minimum of carbon, and if the furnace were tapped at frequent intervals, the resulting pig-iron would be low in carbon content. The reverse of these conditions generally prevails, the tuyere and fusion zones being relatively high and the depth of the reducing and preheating zones so great that the reduced iron becomes highly carburised. Unfortunately, the first case corresponds with a high fuel consumption per ton of pig-iron produced whilst the latter accompanies low fuel consumption.

In the foundry industry the demand for better pig-irons is likely to be increasingly insistent owing to the higher mechanical strength demanded by engineers. This demand is already influencing the mind of the modern foundryman towards the use of pig-irons containing low total carbon percentages, and unless the supply of such iron is forthcoming at a reasonably low price the use of steel scrap as a diluting agent in the cupola charges will increase and must, as a consequence, diminish the demand for high-carbon foundry pig-iron. The use of lean ores in the blast furnace burden tends towards lower-carbon irons, but, as such burdens demand more fuel for their smelting and a lowering of the blast temperature if a low enough carbon content is to be assured, the outlook for a low-priced product is not bright. The increasing use of steel scrap in open-hearth steel making is already having its effect on the production of pig-iron. One of the immediate problems of the future for the blast-furnace man is likely to be, if it is not already, that of producing cheaply, on a low fuel consumption, pig-iron low in total carbon content from ores low in phosphorus.

At the moment, the cheapest pig-iron production goes hand in hand with high-carbon irons and comparatively low coke consumption. In this connection it should be remembered that a pig-iron rich in silicon and phosphorus may have an apparently low carbon content, as compared with a low-silicon hematite pig-iron. It is the matrix in which the silicon and phosphorus constituents occur that gives the index to the carbon content. A hematite iron containing, say, 1.5 per cent. silicon and 4.0 per cent. total carbon has a matrix of 4.2 per cent. carbon content, whilst a phosphoric iron containing 3.5 per cent. silicon, 1.5 per cent. phosphorus, and 3.5 per cent. carbon has a matrix containing about 4.6 per cent. carbon. The modern foundryman is on the look-out for pig-iron which has a matrix containing not more than, say, 3.2 per cent. carbon. The only pig-irons which have given such a matrix appear to be those produced in small furnaces using cold blast and burning coke at a much lower rate per square foot of hearth area per hour than in modern hot-blast furnaces. The pigs produced from these old furnaces would bend before breaking, and there are records of 1-in. square bars tested at 54-in. centres transversely which deflected more than 1½-in. before fracturing. There is an accumulation of evidence that such iron, when re-melted and cast, has a more homogeneous structure than an iron of similar chemical analysis made from mixtures of steel scrap and high-carbon pig-iron. It apparently cools within the sand mould in such a manner that the metal when cold is not internally stressed or strained—a condition obviously associated with the long life observed in the case of the engine beams and connecting rods of Boulton's and Watt's days. How is the modern blast-furnace to be operated so as to produce such iron?

The Foundry Cupola.

Like its larger brother, the blast furnace, the cupola furnace depends on direct contact of the metal with incandescent fuel in a long vertical chimney shaft. The cupola remains much in the same form as was common a century ago, there being records of cupola furnaces having the same ratio of height to diameter as in almost standard cupolas of to-day. But, like the old blast furnaces, the tuyeres were of smaller area and the blast pressure was often much lower than that used in modern cupolas. They were extravagant in fuel but rarely burnt or oxidised the iron. To-day, there is still much variation in cupola design and operating practice. Nothing like standardisation in design has yet been attained, and it is not likely that uniformity in the matter of cupola proportions will be possible, for the following reasons:—

(1) The use of increasing proportions of steel scrap in the charges calls for a certain rate of coke combustion per square foot of hearth area (taken at tuyere level) per hr. The height of the charge column is governed by the rate of fuel combustion at the fusion zone, and in this case by the amount of preheating required by the steel, necessary for

* Bulletin of the British Cast Iron Research Association.

the control of the carbon content in the molten mixture of carburised steel, pig-iron and scrap. (2) For the re-melting of large proportions of light phosphoric iron scrap different tuyere proportions, blast pressure, charge column height and amount of preheat are required, the height of the fusion zone, in relation to the cupola bottom and tuyere level being important. (3) The re-melting of heavy scrap and pig-iron charges calls for special proportions in the diameter and height of the charge column, blast pressure, and rate of melting. (4) Where the use of very miscellaneous sizes and composition of scrap and pig-iron is compulsory and rapid melting imperative, the use of a receiver is sometimes desirable, placed either immediately below the cupola well or in front of the tapping spout. For efficient service this arrangement affects the fusion-zone level and height of charge column. (5) Where long periods of melting, with a rapid succession of small-weight tappings is desired, the design of the cupola has to be modified to suit such conditions.

It will be seen from the above that, just as the proportions of a blast furnace and speed of fuel-burning must vary for special conditions of the burden (chemical and physical composition, etc.), so in the cupola the design and operation must follow such variations in the physical and chemical composition of the fuel and metal charges. In both cases the fuel consumption per ton of product is affected by the amount of slag required to assist desulphurisation of the metal and for the fluxing of earthy matters in the fuel and carried by the pig-iron and scrap.

The economy in fuel is greatly affected by the position of the fusion zone and by the effectiveness of the air supply. In dealing with melting propositions the British Cast Iron Research Association has been collecting data relating to the design, melting efficiency, and general operation of representative types of cupolas, some hundreds of re-melting furnaces being under survey. The fundamentals of the process, as related to fuel economy, wear and tear of linings, metal losses during melting, speed of melting and the function of slags are being studied in relationship to cupola design and operation. As in the case of the blast furnace the size, number, shape, and position of the tuyeres; the contour of the linings, their resistance to erosion and heat; the height of the fusion zone and depth of charge column; the air supply and resulting gas compositions at the different horizons from axis to lining; the effect of radiation, and other perhaps minor details are of importance and must be studied carefully and the findings put into practical action if cupola melting efficiency is to be improved. The possibility of effective fuel combustion in long furnaces of the vertical shaft type is well known, but unlike the blast furnace, the cupola is intermittently worked, melting for comparatively short periods with intervening long periods of rest and the application of recuperative systems for utilising the heat energy in the escaping gases is attended by many practical difficulties.

Need to Utilise Maximum Heat.

Bearing in mind the primary fact that intermittent working is a commercial necessity, it must be clear that the fuel used should be effectively burnt, with as little free oxygen as possible, at the lowest practicable horizon and at the correct rate for ensuring that the gases escaping from the cupola top have little sensible heat and are mainly CO_2 and nitrogen during the major portion of the melting period. In other words, the aim must be to utilise the heat energy between the tuyere and the stock-line horizons, without escape of any combustible gases at the throat, the spent gases passing to the stack with the minimum of sensible heat. The blast furnace of olden time often approximated to this condition wherever the open-topped furnace was worked so carefully that the head or throat gases escaped with little or no combustible content. The fusion zone was low, there was little radiation of heat through the thick walls, the whole of the heat energy of the fuel being expended in preheating, reducing, carburising, fluxing, melting, alloying, and superheating the succession of iron-holding vehicles, and in heating and super-heating the air, fuels, fluxes, and slags. There are still living Black Country iron-workers who remember blast furnaces which used air cold enough to pass through leathern ducts to the tuyeres, operated by intelligent "keepers" who knew that when the furnace top was practically cold, with only lambent and feeble CO flames escaping spasmodically through the top of the charge, the best iron was being made, and with the minimum of fuel.

The modern blast furnace, unlike the cupola, ejects more than half the heat energy in the fuel through the throat, largely in the form of combustible gases which, if efficiently used, make the rapid-smelting furnace of to-day a machine of high efficiency, capable of producing pig-iron at a low cost and in large quantities, in addition to yielding supplies of gas much more than sufficient for the power requirements of the furnace plant and which have a commercial value commensurate with the efficiency of the blast furnace as a gas-producer unit. In these days many blast furnaces produce enough slag of sufficient commercial value to reduce still further the cost of the pig-iron smelted. It should not be forgotten, however, that the temptation to produce slags of tough silicious type suitable for ballasting and road making, tends towards the yielding of pig-iron high in carbon and silicon contents.

In conclusion, it should be noted that considerable attention is being given to improvements in cupola design and operation. Many old suggestions have been revived and, in the light of modern knowledge, some of them bear evidence of sound judgment and give promise of success. In the main, most if not all the most promising developments are the result of a closer study of the fundamentals already referred to. The proposals to use the escaping gases for heating the blast generally ignore the difficulties incidental to intermittent working and to the use of excessive temperatures in the tuyeres. There is increasing interest in foundry circles concerning the more scientific interpretation of melting processes and an increasing desire to obtain economies in fuel and a reduction of melting losses. By the foregoing consideration of the parallel problems of the blast furnace and cupola the writer is hopeful that the suggestions outlined, brief and possibly somewhat disconnected as they are, may be useful in indicating the directions in which further advance may be possible in British blast-furnace and foundry-cupola practice.

French Foundry Exhibition and Convention.

All grades of members and all connected with the member firms of the British Cast Iron Research Association are invited to join the party being promoted by the Institute of British Foundrymen to visit Paris during the period September 6 to 11 for the Foundry Convention and Exhibition, and those who can do so are recommended to join this party.

For those who cannot devote the whole of this period to the visit, the Association is arranging a party for a short visit for the sole purpose of visiting the Exhibition, provided there is an adequate demand. This will leave London on Thursday, September 8, and will return with members of the other party on Sunday, September 11. Members of the Association have been circularised fully with respect to these two visits, and should these fail to reach all those interested, further copies will be supplied on application to the offices of the Association, 24, St. Paul's Square, Birmingham.

Belgium Honours French Foundrymen.

One of France's most prominent foundrymen, Monsieur Emile Ramas, Managing Director of Société Française Metallurgique Griffin and Honorary President of the French Foundrymen's Association, has, on the proposition of the Minister for Foreign Affairs, been elected a Chevalier of the Order of Léopold of Belgium. M. Ramas is an honorary member of the Institute of British Foundrymen. We congratulate M. Ramas and the French Foundry Technical Institution on the distinction conferred.

Centrifugal Casting of Sheet Bars.

Before a recent meeting of the American Society for Steel Treating MR. LEON CAMMEN described the sheet-bar centrifugal casting machine, of which he is the inventor, and which was referred to in the JOURNAL some time ago, when the method was first devised. Since then the machine has been tried out, and the author gives some indications of its economic possibilities.

Remarking that centrifugal casting of sheet bars is, for all practical purposes, a new art, he states that while several attempts have been made in the past, none of them led to satisfactory results, and practically all such attempts were usually abandoned after a few trials and without ascertaining the reasons which prevented success. Referring to the drawings one will see that the barrel part of the mould resembles a mould for casting tubular shapes. It differs from such a mould, however, because of the presence of partition lugs B. Assume now that this mould is employed in the same manner as one would employ a mould for making tubular castings, as actually has been done by a number of would-be inventors of centrifugal bar casting. One would suppose that the problem is simple. Centrifugal force throws the metal to the wall, and if the metal be delivered to the mould as shown, it ought to be thrown to the bottom of the cavities between the partition lugs and form small bars therein. It actually does this in so far as the forming of the bars is concerned. The only trouble is that the metal thus formed is absolutely worthless. A clear understanding of the reasons for this failure will give an idea as to the metallurgical mechanism of centrifugal-bar casting.

The mould shown in Fig. 2 spins on a horizontal axis. The partition lugs may be anywhere from 5 in. to 15 in. long, the inside diameter of the mould from 50 in. to 100 in., and the speed about 6,000 ft. per min. on the inner surface. When molten metal is coming down from the spout into a mould of this size and running at such a speed, it is apt to be hit by the partition lugs and broken up into a fine spray. This spray instantly chills in the air and comes down into the metal in the form of shot. Some of this shot is re-melted and reincorporated into the metal, some of it is not. The result is that when the bar is rolled, the cold shot is knocked out and holes are left in the rolled product. Some years ago at the works of a certain electrical company bars were made by this process. After casting they looked well enough, but when rolled out into sheet the product had more the appearance of a screen than of sheet.

The difficulty has been overcome in the Cammen process by the construction shown in Fig. 1. The metal is teemed against the smooth-walled, restricted neck E of the mould; here the metal is picked up by the rapidly-spinning mould and pressed by centrifugal force against the wall of the

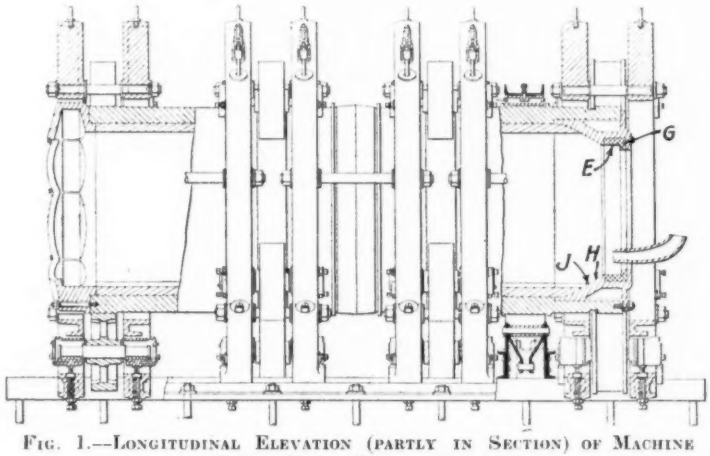


FIG. 1.—LONGITUDINAL ELEVATION (PARTLY IN SECTION) OF MACHINE WITH INSIDE MOULD DIAMETER OF 53.5 IN.

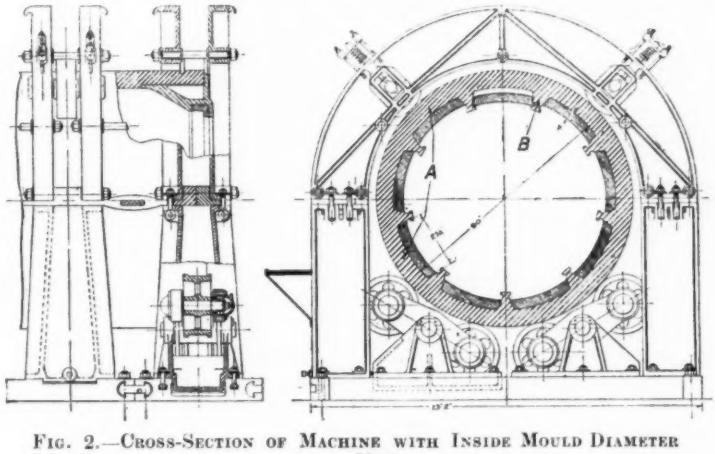


FIG. 2.—CROSS-SECTION OF MACHINE WITH INSIDE MOULD DIAMETER OF 90 IN.

CENTRIFUGAL BAR-CASTING MACHINES.

mould. It cannot get out of the mould because of the presence of the collar G, and therefore it has to go the other way. It is thus forced down over the shoulder H, gaining in centrifugal force as this is done, because of the increase in diameter. By the time the metal reaches the beginning of the partitions at J, it is already spinning at the same rate as the partitions themselves. There is therefore no relative motion between the two and no blow, the metal generally flowing around the shoulders of the partition lugs and filling the spaces in between. This is what is actually happening in the machines and resulting in the production of bars absolutely free from cold shuts. The use of this device at the end of the mould, called the "bottle neck," is one of the characteristics of this process.

In contradistinction to centrifugal tube-casting, centrifugal bar-casting permits the handling of large amounts of metal from perhaps 5 or 6 tons for sheet, bar and wire-rod moulds up to some 30 tons per machine in rail, and structural steel-billet casting. Because of this, a close control can be obtained on the rate at which molten metal is delivered to the spinning mould. As the first metal comes in it instantly freezes, probably close to the beginning of the partition lugs. The next metal, however, flows a little way over the hot metal previously solidified, rather than over the cold wall, which gives it a chance to reach further out into the mould and really produces an equivalent of tube casting in a hot mould. In this way, from the first metal teemed from the ladle, a thin layer is formed the full length of the mould, which may be anywhere from 6½ ft. to 14 ft. and more long. As the next metal comes in, it is flowing over the layer of extremely hot metal which has just solidified. It is important to teem the metal from the ladle into the machine at such a rate that at no time should there be a layer of molten metal present of a thickness greater than, say, ¼ in. As will be made clearer later, the rate of teeming is one of the most vital influences affecting the structure of cast bars.

A continuous process now takes place. As more molten metal is added at the top of the layer of molten metal already present, the bottom of this layer solidifies and in this way the thickness of the solid layer is increased while that of the molten layer stays approximately without change. This has several results. In the first place the solidification of the metal proceeds at a fast rate so that roughly not more than 30 to 45 sec., and possibly much less, elapses between the time the metal leaves the ladle and the time it solidifies in the mould. It is the rapidity with which the metal freezes that makes it practically impossible for segregation to take place.

The question may be raised as to what are the advantages of centrifugal-bar casting as compared with the present method of ingot casting and blooming. Not enough work has been done yet to establish with certainty that centrifugally-cast material possesses properties essentially superior to steel, well made by the conventional process. It has been found that if the metal is dirty in the ladle, it will be dirty in the casting, so that centrifugal casting is not a cure for poor furnace operation. On the other hand, there is good reason to believe that, in properly-made centrifugally-cast metal, segregation will be entirely eliminated or at least greatly reduced.

The main value of centrifugal-bar casting lies, however, in the matter of costs. The reduction of cropping from an average of 12 per cent. (running as high as 20 per cent. in some special cases, such as rails) to about 2 per cent., and the elimination of the entire blooming operation with all it implies, are equivalent to a reduction in costs of from $3 (12s. 6d.) to as much as $6 (25s.) per ton on standard products. Further, a committee of the American Iron and Steel Institute recently made a report on quality classification and average extra costs above base of various kinds of steel blooms, billets and slabs. The special requirement of one class is that surface be free from visible imperfections. Centrifugally-cast bars, properly made, are free from such imperfections on three sides always, and the fourth (innermost) side can be milled at a cost of about 5d. per ton, while the average extra cost above base as specified by the committee is 10s. 6d. per ton. In another class a similar extra 10s. 6d. is allowed for freedom from piping obtained in ordinary ingots by special top discard. As centrifugally-cast bars are naturally free from piping, except possibly on the innermost face (and this can be got rid of by milling), practically the entire extra goes into extra profit with the new process. In a further class an extra cost of £1 is specified for a combination of special requirements of the two classes just discussed. It becomes practically extra profit for makers of centrifugally-cast bars, and the same applies to steel of forging quality. If one adds to the above the saving indicated by the report attached to the author's previous Paper, there will be a difference in costs between centrifugally-cast products and those made from ingots cast in stationary moulds of 25s. to 35s. per ton. This difference in costs, even apart from possible improvement in the quality of products, would appear to serve as sufficient justification for the development of centrifugal casting.

To existing steel plants the elimination of the blooming-mill—says the author in an extract of the Paper made by "The Iron Age"—will not be entirely welcome, perhaps. Few like to think of scrapping equipment that has cost a large sum of money, even if economies are to be secured by such an operation. New mills will, however, appreciate a substantial diminution in initial cost.

A Note on Oilstones.

By C. A. OTTO.

It is no exaggeration to say that the oilstone is the patternmaker's most important tool. This is not always realised, and many quite experienced men do not know how to keep the oilstone in proper order or how to sharpen tools in the correct way. Plane irons and broad paring chisels require to be square and straight across the face. Because of this, in sharpening these tools the best way is to set the oilstone square to the edge of the bench at such a distance as to be conveniently reached and to stand square in front of it, grasp the plane iron by its upper portion in the right hand, and, with the left thumb underneath, bring the four fingers firmly down on the front of the iron close to the edge, then apply the iron to the stone, keeping the edge square to it, and rubbing the iron firmly the full length of the stone backwards and forwards. A few strokes will bring up the edge. The iron should be tilted slightly and each corner rubbed down just sufficient to keep the corner from leaving a ridge on the timber when planing, then turn the plane iron, or chisel, on its face, press it flat on the stone, and then rub it slightly forward to take the "wire" off the edge, when it will be found that the plane iron or chisel has a straight, true edge.

An oilstone should not be less than 2 in. wide, and a second stone should always be kept in use. Several kinds of oil are used for stones, and of these the only one that should never be used on an oilstone is linseed oil, raw or boiled, as it dries and clogs up the pores of the stone, even if carefully wiped after using, and soon makes the best stone useless. Neatsfoot, sweet, olive, castor, or any of the compound oils are safe and good for use on stones and gouge slips. Oilstones become hollow and full of ridges in use, and it is difficult to sharpen plane irons or chisels properly on them. It should be the aim to avoid such a condition, and one way is to practise sharpening edge tools properly.

Good oilstones have a certain degree of porosity. If there is any doubt as to hard and soft places in the stone a damp sponge passed over it will show them as soft places and absorb the moisture more quickly than hard or even-grained parts. An oilstone should not be too porous, or it will absorb the oil, harden, and soon become valueless. To test a stone for keenness, the edge of the thumb should be passed along the face of it; the difference between several stones can easily be noted if this is done. A good oilstone is one of uniform quality throughout with no hard or soft places. It should be keen without being coarse in the grain, and neither too hard nor too soft.

Alloys of Iron and Manganese Containing Low Carbon.*

By Sir Robert Hadfield, Bt., D.Sc., D.Met.

This is a voluminous and exceedingly elaborate Paper dealing with researches conducted by the author in regard to the properties conferred by manganese upon iron in the practical absence of carbon. It is divided into two main parts, the first of which deals with previous researches by the author and other investigators, under three sections. In the first of these the author recalls that it was in 1888 that he communicated his first two Papers to the Institution of Civil Engineers on "Manganese Steel" and "Some Newly Discovered Properties of Alloys of Iron and Manganese." These were followed by a further Paper on "Manganese Steel" before the Iron and Steel Institute, and later, in 1893, by a Paper before the American Institute of Mining Engineers at Chicago on "Iron Alloys with Special Reference to Manganese Steel."

The author points out that these Papers described his discovery of the steel known as manganese steel, which is now accepted as meaning specifically an alloy containing about 12 to 14 per cent. manganese, 1 to 1¼ per cent. carbon, and the balance iron, about 85 per cent.—a valuable product which was practically the beginning of the important modern era of alloy steels, comprising those of the binary, ternary, and quaternary types. The author followed up these original researches by similar investigations on alloys of iron with silicon, aluminium, nickel, chromium, tungsten, cobalt, molybdenum, and other elements, and these were described in various Papers read, between the years 1889 and 1915, before the Institution of Civil Engineers, the Iron and Steel Institute, and other scientific and technical bodies.

After brief reviews of Faraday's work on alloys of iron and Mushet's early experiments, the author, in Section 2 of his Introduction, states that it was the metal manganese in its combination known as ferro-manganese which led to the discovery of manganese steel. At the time of his early experiments manganese was only just beginning to be available in the form of rich ferro-manganese containing 60 to 80 per cent. of manganese, also in the high manganese-silicon alloy known as silico-spiegel. The production of these ferro-alloys in the blast furnace, nearly fifty years ago, bearing all the circumstances of the time in mind, was in itself a great achievement, and the highest credit is due to those who were responsible for their successful manufacture and introduction.

Continuing the history of the steel alloys and coming down to later times, the author emphasises the importance of the early work carried out by the Terre Noire Company in France, giving details of mechanical tests conducted by them on specimens of rolled and forged steel containing different quantities of manganese. He then passes on, in Section 3, to a short review of the contributions to the subject made by such workers as Guillet, Arnold, Burgess, Aston, Kasé and Strauss.

The Present Research.

In explaining the objects of his present research, the author remarks that in view of the fact that the manganese steel now used industrially contains considerable percentages of carbon varying from about 0.90 to 1.50 per cent., and that both carbon and manganese are instrumental in producing the remarkable qualities of this alloy, the importance of ascertaining definitely the properties conferred by manganese itself upon iron, that is, in the practical absence of carbon, has always been apparent. It was this consideration that led him to prepare the various alloys of iron and manganese he describes, some of them made many years ago, and in which the carbon was kept very low. Thus, comparison can be made between the qualities of these and of the materials represented by his earlier researches—namely, between the materials representing the two types of alloys of iron and manganese, the one with carbon varying from about 0.50 to 1.20 per cent. and the other with little or no carbon, 0.08 to 0.20 per cent., while keeping these alloys, as far as practicable, free from other elements: that is, they were generally but little influenced by the presence of other elements. The manganese varied from 0.06 to 38.90 per cent., silicon from 0.03 to 0.70 per cent., sulphur from 0.047 to 0.120 per cent., and phosphorus from 0.036 to 0.070 per cent. The various specimens were obtained in both the cast and the forged form, and in each case their qualities were determined: (1) In the untreated condition, *i.e.*, as forged or as cast; (2) after annealing by heating to 860 to 890 deg. C. and cooling very slowly; (3) as water-quenched from a high temperature. The tests, carried out on 13 specimens, included the following: (*a*) For the cast material: bending tests on cast strips and transverse bars; also Brinell ball hardness and hammer-hardening tests. (*b*) For the forged material: bending tests on forged strips; tensile tests showing the yield point, tenacity, elongation, and reduction in area; Frémont shock tests on specimens—(*a*) nicked, (*b*) without nicks; hammer-hardening tests; Brinell ball hardness tests. In addition, in the case of forged material, a complete series of the following tests was made: the specific magnetism of each of the 13 specimens, from 1.68 to 38.90 per cent. manganese; electrical resistance; heating and cooling curves; microstructure of the specimens; their corrodibility.

A number of tests were also carried out upon an unforgeable alloy containing 83.50 per cent. of manganese—that is, similar to high-percentage ferro-manganese, but with quite low carbon, namely, 0.29 per cent. In this case, owing to the brittle character of the material and its non-forgeability, a similar series to that made upon the remaining materials was not possible, and the tests actually carried out were of a character more suitable to display its qualities both as cast and also as affected by heat treatment.

The results of the tests are given in full detail in a series of tables too voluminous for reproduction in our columns. In discussing them the author remarks that the examination of this series of iron-manganese alloys has not indicated that any of the series has really valuable or useful qualities for industrial applications. The special qualities called for in industry are now, however, so many and varied that he thinks it impossible to say that a particular alloy or material may not eventually find a special use for which it is better fitted than any other.

It is evident (the author continues) that one characteristic property of manganese steel, namely, non-magnetism, has its origin in the association of the iron and manganese, since it is quite possible to obtain non-magnetic qualities by the use of these two elements alone. Carbon, however, is not without its effect in this connection, and, in fact, the present research shows that in the practical absence of carbon, manganese steel containing 12 to 13 per cent. manganese would be quite strongly magnetic even in its water-quenched condition—namely, about 12 per cent. specific magnetism, compared with pure iron as 100. The presence of carbon, in fact, enables non-magnetic qualities to be obtained with much lower percentages of manganese than otherwise. While in the iron-manganese alloys practically free from carbon at least 16 per cent. of manganese is necessary, the author has by the addition of 1 per cent. of carbon obtained non-magnetic qualities in alloys containing as low as 7 per cent. manganese.

Carbon also influences over a certain range of manganese percentage the degree of permanence of the non-magnetic qualities under the influence of heat treatment, and it is, in fact, the prime cause of the development of magnetism in man-

* Summary of a Paper read before the recent Annual Meeting of the Iron and Steel Institute.

ganese steel by heat treatment. Iron-manganese alloys, in the absence of carbon, are, on the other hand, apparently not influenced in their magnetic character by heat treatment.

It is further evident that the special features of manganese steel as regards its mechanical qualities, namely, its high tenacity combined with extraordinary ductility, and a remarkable propensity for hardening under deformation, also have their basis in this iron-manganese combination, although such alloys do not display these qualities to the same enhanced degree as manganese steel, and require a considerably higher percentage of manganese. The presence of carbon to the amount of 1.25 per cent. adds very considerably to the tenacity, also to the ductility and work-hardening qualities, and further enables alloys of comparatively low percentages, *i.e.*, even down to 4 or 5 per cent., to display such characteristic qualities to an appreciable degree, although not to the same extent as manganese steel properly so called, that is, the alloy with 13 per cent. manganese.

The author considers that the researches of Guillet, Arnold, Kasé and his own have now well established the mechanical qualities of the iron-manganese series of alloys in their main features. Of these, apart from the qualities which contain above 16 per cent. manganese up to, at any rate, 39 per cent., the most marked feature is the comparative brittleness of the alloys containing from about 4 to 10 per cent. manganese with a maximum of brittleness at about 7 per cent. Material with this percentage, while possessing quite appreciable hardness and cohesion, is incapable of much deformation, and, further, the nature of the cohesion is such that it is apparently easily influenced by small factors. What these factors are is not at present known. On either side of 7 per cent. the alloys partake of this character, more or less according to their proximity in composition, but finally merging into the characteristics of high tenacity and ductility previously referred to at the higher percentage, and, on the other hand, towards the low tenacity and comparatively high ductility of iron itself at the lower percentages.

In the author's original research on alloys of iron manganese and carbon, in which the carbon percentage in relation to that of manganese was approximately as 1 to 10, a somewhat similar characteristic, that is, of hardness and brittleness, was specially noted, *i.e.*, at what was then known as the brittle percentage containing about 5 per cent. manganese. This particular alloy containing about 0.5 per cent. carbon was so brittle that it could easily be pounded with a hand-hammer, its hardness being over 600 Brinell, sufficient to scratch glass. Here again the brittleness of this alloy appears to be connected with a similar brittleness found, although in not so marked a degree, in the alloys of iron and manganese with low carbon content containing from 4.00 to 10.00 per cent. manganese. While the presence of carbon undoubtedly adds to the hardness and brittleness in such alloys of comparatively low manganese percentage, this characteristic is evidently derived mainly from the combination of the iron and manganese.

Conclusion.

In his concluding remarks, the author states that in summing up the general results of the present research, and in comparing the physical properties of the materials described, one of the features of outstanding importance is undoubtedly that they bring out very clearly the literally marvellous influence of carbon. On consideration, he finds it not a little astonishing that the production of manganese steel would probably not have been possible had the ferro-manganese used in his researches contained a low percentage of carbon; 80 per cent. ferro-manganese ordinarily contains 6 to 7 per cent. carbon.

The result of the present research clearly shows that alloys of manganese without carbon do not appear to be of commercial value. There may be applications here and there for some of the materials, but so far as at present ascertained, characteristics or qualities which indicate value from the industrial point of view have not been found. Ferro-manganese as ordinarily produced contains a ratio of about one-twelfth of carbon to manganese in 80 to 84 per cent. ferro-manganese. Consequently in the manufacture of manganese steel there must always be about 1 to 1¼ per cent. of that element present in the steel produced, which is one of the chief reasons for its valuable properties.

At the time of the author's discovery, the experiments and researches he made were carried out with ferro-manganese of the type then produced by Mr. Pourcel. Thus the manganese steel produced contained the quite considerable percentage of carbon mentioned. Take away that percentage of carbon and the product becomes of little or no value. It will thus be seen that fortunately this valuable product, ferro-manganese, was available for the author's early research work in 1882 to 1890 on alloys of iron and manganese, otherwise his immediate research at that time would probably not have resulted in anything more than products of academic value. Therefore, ferro-manganese, with its one-twelfth ratio of carbon, is a valuable blast-furnace product, not only because of the manganese in it, but also the carbon. Once more is shown the wonderful nature and value to the metallurgist—in fact, to the human race generally—of the element known as carbon.

In such cases also as high-speed steel and many others an appreciable percentage of carbon is absolutely essential to their character. Singularly enough, and in contradistinction to this, it has been and is being found that certain other alloys of iron, if containing carbon in any quantity, say about 0.50 per cent. and upwards, are not nearly so valuable as when the carbon is reduced to the lowest possible point, say 0.10 per cent., and even under.

The silicon steel which the author described to this Institute in 1889 owes in part its valuable properties not only to the high percentages of silicon present but also to the low percentage of carbon. The modern chromium steel alloys are much better in their resistance to corrosion in the absence, or presence only in low percentages, of carbon. This, too, also applies to the new types of nickel-chromium steel alloys. On the other hand, manganese-iron alloys with little or no carbon do not seem to offer any practical employment; they only become valuable in the presence of quite high percentage of carbon, 0.90 to 1.50 per cent.

It may be mentioned that in carrying out this research, there have been made 806 tests of various kinds, comprising mechanical, chemical, physical, metallographic, and other tests, involving considerable time, labour and expenditure.

Monel Cast Iron.

Dr. Disch, in an article published in the B.C.I.R.A. Bulletin dealing with American Foundry Practice, states that experiments on alloy cast irons were seen at the laboratories of the International Nickel Company, at Bayonne. A high-frequency induction furnace is used for the experimental melts. American practice in the addition of nickel to cast iron for many purposes is well known, but an interesting development is the production of a non-magnetic iron with considerable resistance to corrosion, containing 20 per cent. of nickel and copper in the Monel metal ratio, together with 2.0 per cent. of chromium, 3.0 per cent. of carbon and 2.5 per cent. of silicon. This is intended as a cheap substitute for bronzes in chemical plant, etc. This Monel iron is grey, and gives about double the deflection of the ordinary grey iron with 2.0 per cent. silicon on the transverse test. It has small shrinkage and machines like ordinary grey iron. For great resistance to corrosion, as much as 15 per cent. of chromium has been added, giving a harder alloy. These irons are still in the experimental stage, but have interesting possibilities.

Change of Address.

Owing to the local authorities having now renumbered North Road, Darlington, the address of Messrs. Robson's Refractories, Limited, is now No. 16 North Road, instead of No. 1, as previously.

Methods for Gating Tensile-Test Bars of Sand-Cast Non-Ferrous Alloys.

By Robert J. Anderson*, D.Sc.

Introduction.

In American practice on certain non-ferrous specification castings, as well as in routine technical control, tensile tests are made on bars either cast coupon (integral) with the casting or cast in individual moulds from the same pot of metal as the casting. The integral-cast coupon has many undesirable features connected with it, and many metallurgists and engineers have come to the conclusion that the separately-cast bars are to be preferred. Naturally, with the separately-cast bars, the conditions of casting must be definitely standardised, particularly as regards method of gating, hardness of ramming, condition of sand, venting, thickness of mould, pouring temperature, and other germane factors. However, when suitable standard conditions are maintained, and the gating of the bars is correct, the results are very uniform and reliable. If the tensile values obtained from the separately-cast bars do not indicate the strength of the casting itself, they at least indicate the quality of the metal going into

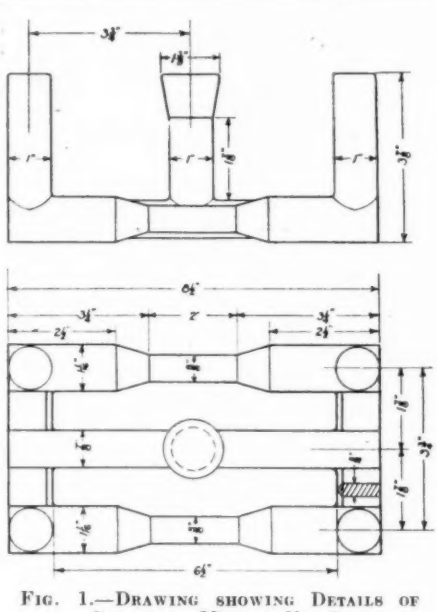


Fig. 1.—Drawing showing Details of Gating by Method No. 1.

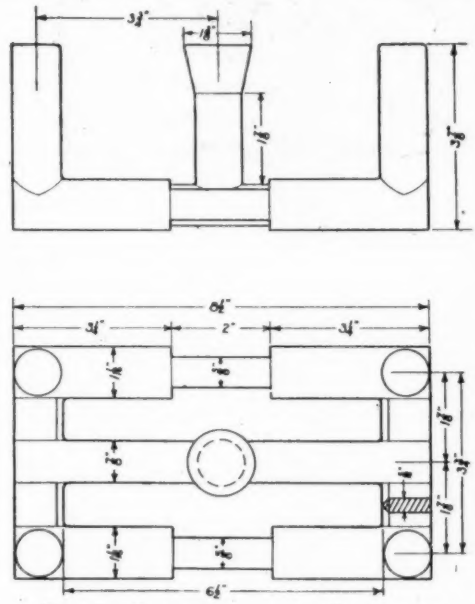


Fig. 2.—Drawing showing Details of Gating by Method No. 2.

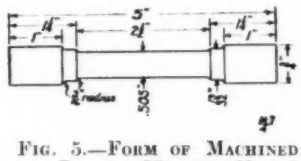
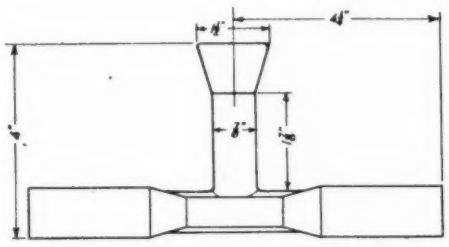


Fig. 5.—Form of Machined Bar for Methods Nos. 1 to 3 inclusive.



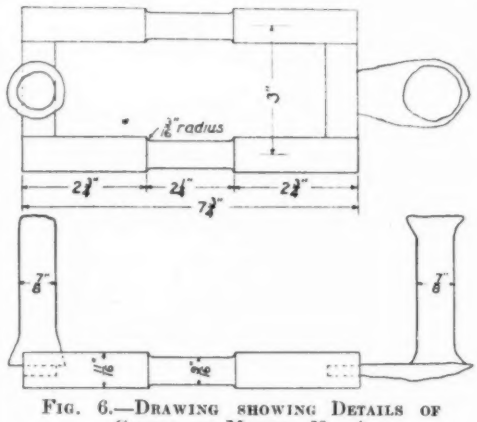


Fig. 6.—Drawing showing Details of Gating by Method No. 4.

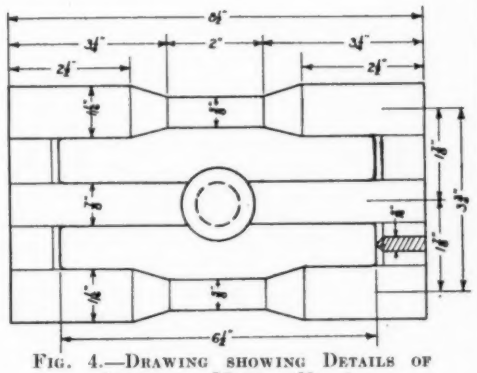


Fig. 4.—Drawing showing Details of Gating by Method No. 3.

* President, Robert J. Anderson, Inc., Chemists, Metallurgists and Consulting Engineers, 2416-38 Beekman St., Cincinnati, Ohio, U.S.A.; Vice President and Consulting Engineer, Aluminium Industries, Inc., Cincinnati, Ohio, U.S.A.

the casting. In point of fact, the foundryman in many cases has no control over the strength of given designed castings, and the technical control can be concerned only with the quality of metal being run. Whilst the separately-cast bar does not give the strength of the casting, neither does the integral-coupon bar. It is well known to foundrymen that a considerable range of tensile properties can be obtained in the integral coupon, depending upon its position with respect to the casting, runners, risers, etc.

The object of the present article is to show pictorially a number of different methods tried by the writer for gating sand-cast bars, the preferable method being indicated. Many erroneous conclusions have been reached as the result of data based on faulty test bars, and if the separately-cast bar is not to come in for adverse criticism, then such bars must give uniform results under standard conditions.

The conclusions drawn in the present article are based on a very considerable number of tensile tests, and similar conclusions have been arrived at by other investigators. Tests were made by the writer with the gating methods shown, as well as others, on a large number of commercial casting brasses, bronzes, and aluminium alloys, excepting high-shrinkage brasses of the type of aluminium brass and manganese bronze.

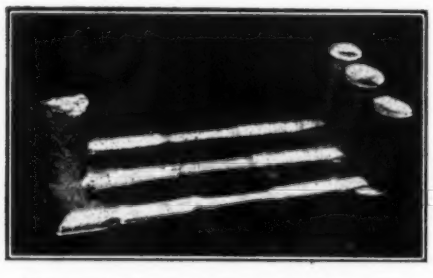


Fig. 3.—Photograph of Bar Cast by Method No. 2.

Gating Methods Tried.

In the accompanying figures are depicted some of the methods used in gating tensile-test bars for sand-cast non-ferrous alloys. The first three methods were in use, or recommended, by different foundries. While many methods of gating other than those described here have been used by different foundries, the accompanying illustrations will serve to illustrate types of good and poor gating. Modifications of the good methods of gating can, of course, be made as circumstances require.

Method No. 1.—The method of moulding test bars in method No. 1 is illustrated by the drawing of Fig. 1. As is shown, two bars are cast in a mould with risers at each end, using a central pouring gate with distributing runners. The bars are moulded half in the drag and half in the cope, being poured in a horizontal position. This method has the inherent fault of permitting liquid metal to overlap in the bars, whereby an oxide skin may be formed, foreign inclusions (sand particles) swept into the bars, or overlaps formed, thereby giving low tensile values. Bars cast by this method tend also to give non-uniform results.

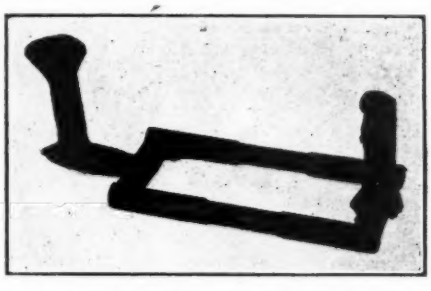


Fig. 7.—Photograph of Bar Cast by Method No. 4.

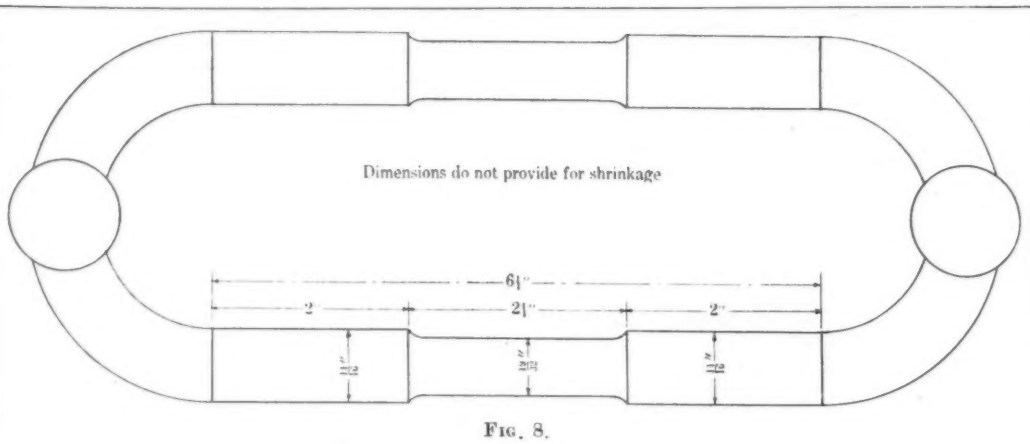
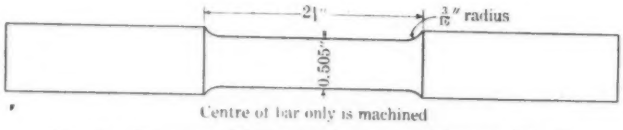


Fig. 8.



Centre of bar only is machined

Fig. 9.—Form of Machined Bar for Method No. 5.

Method No. 2.—The method of moulding test bars in method No. 2 is shown by the drawing of Fig. 2. This method of gating is the same as in method No. 1, but the shape of the test bar is different, as will be seen from the illustrations. Fig. 3 shows a set of actual bars cast in a bronze by Method No. 2. The same faults which are present in method No. 1 are also present in method No. 2.

Method No. 3.—The method of moulding test bars in method No. 3 is illustrated by the drawing of Fig. 4. As is seen, no risers are used, the bars simply being cast from a central pouring gate with lead-off runners as indicated. This method has inherent disadvantages due to inadequate feeding, as well as meeting of liquid metal due to its flow in the mould. Bars cast by method No. 3 tend to show low and non-uniform values. Methods Nos. 1 to 3 have been in use at different foundries,

but the results show that they are not to be recommended.

Machined Bars.—Bars as cast in methods Nos. 1 to 3 inclusive were machined to the form shown in Fig. 5. The ends may be threaded or not, as required.

Method No. 4.—The method of moulding test bars in method No. 4 is illustrated by the drawing of Fig. 6 and the photograph of Fig. 7. The liquid metal is poured down a pouring gate at one end, is distributed to a bar at either side by suitable runners, and there is an opposed riser at the other end. Bars cast by this method gave good uniform results and were more free from casting flaws than bars poured by the first three methods. The values did tend to be higher than with methods Nos. 1 to 3 inclusive, because the bar is somewhat smaller, but method No. 4 is plainly a better casting method than the first three described. The liquid metal flows down the pouring gate, divides more or less equally to the two bar cavities, flows through these, sweeping air and any inclusions out, joins, and rises. The gate and riser are ample to ensure adequate feeding.

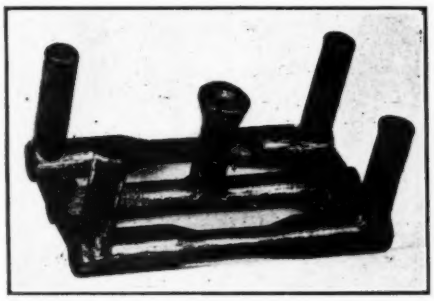


Fig. 10.—Method of Gating Test Bars, particularly Aluminium Alloys. (U.S. Army Air Service.)

Machined bars from method No. 4 are prepared as shown in Fig. 5, the same as for the first three methods.

Method No. 5.—The method of moulding test bars according to method No. 5 is shown in the drawing of Fig. 8, and machined bars were prepared as in Fig. 9. This method of gating is similar to method No. 4, but there is no offset on the pouring gate, and the connecting gates are rounded off. Method 5 has been used by the writer in several foundries with satisfactory results for brass, bronze, and aluminium alloys for technical-control work. The pouring head for method No. 5 may be about 3 ins. to 4 ins. high.

Other Methods.—Sundry other bar-gating methods have been tried by the writer, and their use in various foundries observed. A method used by some foundries, particularly for aluminium-alloy sand-cast bars, is shown in Fig. 10. In this, three bars are poured from a common gate at one end, the metal distributed, and each bar has a riser at the other end. This gives quite satisfactory results. In a similar method, the three bars as shown in Fig. 10 are poured from a single gate at one end, the metal distributed, and a single opposed riser is had at the other end, the three bars being connected with runners at each end. This latter method does not give as uniform results as are desired. The writer's experience is that no improvement is to be had by any gating method over that of method No. 5 (Fig. 8).

In moulding test bars, it is convenient to have the pattern for the bars mounted as a plate, which facilitates production of moulds and tends towards uniformity of results. The bar may be divided half in the drag and half in the cope. Bars may be cast over-size to provide for machining or cast to the desired size and tested with the skin on. The shouldered ends may be designed suitably to fit axial loading grips of the tensile-testing machine, or the ends may be threaded.

Two furnaces have been put out of blast at the Tees Ironworks of Pease & Partners, Limited. The iron-ore mines at Boulby and Ayton have been closed down.

Giant Drum Shaft.

Hollow Forging from 120-Ton Ingot.

In our issue of July 21 we described and illustrated, under the caption of The World's Largest Winding Engine, for the shaft of which the Forge Department of William Beardmore and Company, Limited, were responsible. This shaft was of such dimensions and weight as make it one of the largest and heaviest ever produced for the purpose, and obviously its manufacture required great care during the different stages. It is actually in three pieces coupled together, consisting of the drum shaft in the centre coupled up to a motor shaft at each end. The drum shaft measured 47 ft. 8 in. long, 33 to 42 in. dia. externally, and 18 in. dia. internally, and weighed 52½ tons when finished. It required for its manufacture an ingot weighing 120 tons. After the ingot was cast, it was carefully heated and forged into a bloom of about 70 in. dia. This bloom was annealed and sent to the machine shops where the top and bottom end was parted off and a 20-in. dia. hole trepanned through its length. The hollow bloom then went to the hydraulic forging press shop where it was hollow forged on a mandrell into the drum shaft. The forging was then carefully annealed in a special type of furnace in the annealing shop, and afterwards sent to the machine shops, whire it was rough-turned. A further annealing then took place and the shaft was returned to the machine shops to have the mechanical test-pieces cut off and the machining completed.

The two motor shafts were forged direct from the ingot in the usual way, as these were not of the exceptional dimensions and weight of the drum shaft. The machining of these large shafts called for special care and preparations, and throughout the different stages had to be closely inspected as very close limits were imposed on the dimensions. When the three shafts were coupled together—with bolts which measured 6¾ in. dia.—the complete shaft was put into one of the largest lathes in the shop, finally machined, and carefully tested for alignment to make certain that all the journals were truly in line. The inspection and tests were made to the requirements of Messrs. Preece, Cardew and Rider, Consulting Engineers, London.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

The Price of Cast-Iron Pipes—A Fallacy Refuted.

To the Editor of The Foundry Trade Journal.

Sir,—I have recently received a letter from an engineer, well known in the industrial and gas world, which sets out a series of well-reasoned arguments to show that in national interests purchasers of materials should, as far as possible, refrain from buying abroad; and saying that in the case of cast-iron pipes, buyers are inclined to introduce competition from abroad in consequence of an alleged existence in this country of an Association for controlling prices of the home-made product.

On making inquiries further afield I find the belief to be prevalent that the price of British made cast-iron pipes is controlled, or in some way regulated, among the several makers.

I would therefore like emphatically to state that since the Cast-Iron Pipe Association was dissolved some four years ago, prices have been free and in no way controlled.

Probably in no article of commerce does the direct cost of wages absorb so large a portion of the selling price of an article as does the cast-iron pipe, and the raw materials required in its production. In short, it takes seven tons of British material to produce one ton of cast-iron pipes. It follows, therefore, that for every one ton of pipes imported, the country is deprived of the wages paid in the getting and manufacture of eight tons of materials; wages paid, direct and indirect, representing by far the greatest portion of the selling price.

Is it possible to advance a stronger plea for giving preference to British cast-iron pipes, which are excluded by tariff walls from entering the countries of their competitors?—Yours, etc.,

For the Stanton Ironworks Company, Limited,
E. J. Fox,
Managing Director.

Nottingham, August 9, 1927.

Trade Talk.

The Palmers Shipbuilding and Iron Company, Limited, of Jarrow, have secured a second contract for an oil tanker for the Venezuela Gulf Oil Company, America.

Under the North of England iron trade sliding scale, puddling and other forge and mill wages have been reduced by 5 per cent. In the galvanised sheet trade the percentage on base rates has been reduced from 45 to 42½.

After an unofficial strike lasting eight days, the Clyde riveters resumed work on August 4, on the condition that their Executive Committee will negotiate with the employers regarding a grievance concerning the new price list.

Joseph Evans & Sons (Wolverhampton), Limited, Culwell Works, Wolverhampton, advise us that their London address is now 109, Kingsway, London, W.C.2, their London agents, Dryden, Osborne & Company, having removed from Craven House, Kingsway, to larger offices.

The Welin Davit & Engineering Company, Limited, and the Maclachlan Automatic Boat-Davit Company, Limited, have recently amalgamated their interests under the style of Welin-Maclachlan Davits, Limited, 5, Lloyds Avenue, London, E.C.3, and 55, West Regent Street, Glasgow.

The Caledon Shipbuilding and Engineering Company, Limited, Dundee, have received an order from the Southern Railway Company to build two paddle steamers for their passenger traffic between Portsmouth and the Isle of Wight. Each vessel will be 200 ft. long with accommodation for 600 passengers.

The statement which was freely circulated in West Cumberland during the week-end, to the effect that an Egyptian order for sleepers had been secured by the Workington branch of the United Steel Companies, Limited, is officially denied. The sleeper mill did not restart last Monday, but an order which will provide about three weeks' work is expected almost immediately.

The land, buildings, machinery and other effects of Roger & Company, Limited, the Stockton engineering firm, which is in voluntary liquidation, were offered for sale by auction at Stockton on Tuesday. The main building and land in West Row was withdrawn at £2,000, whilst the pattern and brass shop in Prince Regent Street were sold for £750. The auctioneers were Wheatley, Kirk, Price & Company, of Newcastle.

The London Midland and Scottish Railway recently placed an order with the North British Locomotive Company, Limited, Glasgow, for fifty 4-6-0 superheated express locomotives to handle the heavy passenger traffic between Euston and Scotland. The first of these locomotives has now been delivered, and will shortly be hauling. Several new features have been embodied in the design of the new locomotives, chief of which is the provision of an exceptionally high boiled pressure of 250 lb. per sq. in. The total weight in working order is over 127 tons, the tender carries 5½ tons of coal and 3,500 gallons of water.

New Companies.

Appleton & Howard, Limited, 12, Salisbury Street, St. Helens.—Capital £5,000 in £1 shares. Iron founders. Directors: J. Appleton and T. Crooks.

George Butler (Dudley), Limited, 129, Long Lane, Borough, S.E.1.—Capital £15,000 in £1 shares. Hardware manufacturers. Directors, Elsie M. Hawes, R. W. Clark and W. Brown.

Henderson & Parry, Limited.—Capital £2,000 in £1 shares. To acquire business of iron and steel manufacturers and merchants, now carried on by L. B. Henderson and E. Parry. Subscribers: L. B. Henderson, St. Gerard's Road, Solihull, and E. Parry, Apsley, Anderton Park Road, Moseley.

Minster Ironwork Company, Limited.—Capital £5,000 in £1 shares (2,000 7 per cent. cum. pref. and 3,000 ordinary). To acquire business carried on by George Robson, at 121, Yarborough Road, Lincoln, as the Minster Ironwork Company. Directors: G. Robson, 121, Yarborough Road, Lincoln; D. Bellwood, Bishop Norton, Lincoln; R. L. Williams, 169, Carholme Road, Lincoln.

Smith, Peace (Keighley), Limited, Trinity Works, Lawkholme, Keighley.—Capital £3,000. Sawmill engineers, machine tool makers, etc. Directors: R. Smith, A. Smith and H. Bairstow.

Slater & Crabtree, Limited.—Capital £5,000 in £1 shares. To acquire business of manufacturers of dies for working tin, iron, zinc, copper, brass, and other sheet metals, heretofore carried on at Chesham Road, Summer Lane, Barnsley, Yorks., by E. Slater and H. Crabtree.

Contracts Open.

Bolton.—Cast-iron surface boxes and sundry iron castings, commencing October 1, 1927, and ending March 31, 1929, for the Corporation. The Waterworks Engineer, St. George's Street, Bolton. (Fee, £2 2s., returnable.)

Brixton and Newton Ferrers, Devon, August 31.—Seven miles of 3-in., 4-in. and 5-in. diameter cast-iron water mains, etc., for the Plympton St. Mary Rural District Council. The Engineer, Underwood House, Plympton. (Fee, £2 2s., returnable.)

Durban, August 24.—Ten miles of tram rails, complete with tiebars, fishplates and bolts, for the Corporation of Durban, Natal. Messrs. Webster, Steel & Company, 36, Leadenhall Street, E.C.3. (Fee, £2 2s., returnable.)

Hambleton (Selby), August 26.—Cast-iron and steel water mains, valves, hydrants, and special castings, etc., for the Selby Rural District Council. Mr. R. F. Braithwaite, the Surveyor, 33, Finkle Street, Selby.

Hull, August 22.—500 tons tramway rails, 112-lb. to the yard, Hull section (centre groove), together with fishplates and soleplates, for the Corporation. Mr. T. Thomas, Guildhall, Hull.

Johannesburg, September 8.—(1021)Three 4-ton electrically-driven portal jib cranes, for the South African Railways and Harbours. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Reference A.X. 4,991.)

London, E.C.2, August 24.—384 pairs wheels and axles for wagons, for the Bengal and North-Western Railway Company, Limited. The Offices, 237, Gresham House, Old Broad Street, E.C.2.

Riccall (Yorks), August 26.—Cast-iron and steel water mains, valves, hydrants, and special castings, etc., for the Rural District Council. Mr. B. McGregor Gray, the engineer, New Lane, Selby.

Swansea, August 22.—(1) Cast-iron pipes and specials; (2) waterworks appliances, including valves, hydrants, etc., and (3) water meters, for six months ending March 31, 1928, for the Town Council. The Water Engineer and Manager, Guildhall, Swansea.

Upton-upon-Severn, August 22.—850 yds. of 3-in. cast-iron main with valves, hydrants, etc., and about 184 yds. of 1-in. galvanised iron service pipes, etc., for the Rural District Council. Mr. M. D. Price, the water engineer, Old Street, Upton-on-Severn.

Personal.

Mr. H. N. Baker, who has been for many years in the London office of the Metropolitan Vickers Electrical Company, Limited, as district engineer in charge of erection, has now been transferred to the commercial organisation of that company in London. Mr. G. M. S. Sichel, who has been for some time assistant superintendent of erection at Trafford Park, has succeeded Mr. Baker as district engineer of erection for the London area.

Mr. I. S. Osborn, elder son of Mr. F. M. Osborn, of Oakshaw, Endcliffe Hall Avenue, Sheffield, has joined the board of directors of Samuel Osborn & Company, Limited, Clyde Steel Works, Sheffield. Mr. Osborn is a grandson of the founder of the firm and was educated at the Leys School, Cambridge. He then became an engineering pupil at Davy Bros., Limited, Sheffield, and afterwards graduated B.A. in engineering with honours at Christ's College, Cambridge.

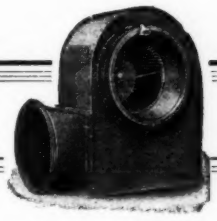
Mr. John Firth, the newly-elected director of Thos. Firth & Sons, Limited, is a son of Mr. Bradley Firth and grandson of Mr. Mark Firth, the founder of the business. Educated at Merlin College, Oxford, he went into the army on the outbreak of war, and served in the Air Force until the Armistice, when he was appointed secretary of Firth's. His successor in the post of secretary is Mr. Harry Green, who has been associated with Firth's more than 30 years, ten of them as assistant secretary. He is a member of a well-known Rotherham family, who have for many years been associated with the ironfounding industry.

Gazette.

A winding-up order has been made against Darwins, Limited, Fitzwilliam Works, Sheffield.

The Holloware Fittings Company, Limited, are being wound up voluntarily. Mr. H. V. L. Heaven, Waterloo House, 20, Waterloo Street, Birmingham, has been appointed liquidator of the company.

The Clarendon Iron and Steel Company, Limited, are being wound up voluntarily. Mr. W. J. Edwards, International Exchange, 156, Edmund Street, Birmingham, has been appointed liquidator of the company.



40 Years' Experience in the Design & Construction of Fans

for

Heating and Ventilation of Buildings, Mines and Ships,
Mechanical Boiler Draught,
Dust Removal and Collection,
High Pressure Blast for Forges, Furnaces and Cupolas,
Fume and Steam Removal,
Cooling and Drying Plants

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Expert Knowledge, High Efficiency, Reliability & Good Service

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DAVIDSON & Co. LIMITED
SIROCCO ENGINEERING WORKS - BELFAST
LONDON - BIRMINGHAM - CARDIFF - BRISTOL MANCHESTER - GLASGOW - NEWCASTLE

PIG IRON
and
High Grade
CYLINDER
IRON
For Motor Castings.

FOUNDRY & FURNACE COKE

J. C. ABBOTT & Co LTD
LLOYD'S BANK CHAMBERS, NEW STREET, BIRMINGHAM.
TELEPHONE: MIDLAND 170.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The position in the Cleveland iron market may be justifiably expressed in the term "stagnation," both the home and export sections experiencing a state of depression seldom approached hitherto in the annals of the industry. As outlined in previous reports for some time past, the home demand has dwindled to almost vanishing proportions, due, in main, to ruthless competition from abroad, which, in the case of Scottish consumers, has almost entirely deprived the Cleveland ironmasters of that one-time flourishing market for their products. To this must be added the fact that many of the works are closed for the holidays, and deliveries are either suspended or curtailed. Unexpectedly makers have conceded an all-round cut in pig-iron prices, and are hoping that this will give buyers confidence to cover their autumn requirements without much further delay. Current quotations are as follow:—No. 1 Cleveland foundry iron, 70s. per ton; No. 3 Cleveland G.M.B., 67s. 6d.; No. 4 foundry, 66s. 6d.; No. 4 forge, 66s. per ton.

In the market for hematite, makers appear to have reached a limit in their price-cutting policy, and although still naming 76s., are not prepared to accept offers below 75s. 6d. for East Coast mixed numbers, with the usual sixpence per ton extra for No. 1 quality. On the North-West Coast, Bessemer mixed numbers are quoted at £4 5s. per ton delivered at Glasgow, £4 9s. per ton delivered at Manchester, £4 11s. 6d. per ton delivered at Sheffield, and £4 13s. 9d. per ton delivered at Birmingham.

Metals.

Copper.—Although occasional setbacks may be noted day by day, the general tendency in warrant copper has been distinctly more active than of late, and values, on the whole, are steadily maintained. Movements in this direction have been supported by the knowledge of decreasing stocks of rough copper in the United Kingdom, by reports of busy Continental cable makers who are buying electro fairly freely, and by the generally good demand in the United States of America, where prices apparently continue to advance.

Official closing prices of standard copper have been as follow :—

Cash: Thursday, £55 12s. 6d. to £55 15s.; Friday, £55 12s. 6d. to £55 13s. 9d.; Monday, £55 3s. 9d to £55 5s.; Tuesday, £55 2s. 6d. to £55 3s. 9d.; Wednesday, £55 1s. 3d. to £55 2s. 6d.

Three Months: Thursday, £55 18s. 9d. to £56; Friday, £55 18s. 9d. to £56; Monday, £55 10s. to £55 11s. 3d.; Tuesday, £55 8s. 9d. to £55 10s.; Wednesday, £55 7s. 6d. to £55 8s. 9d.

Tin.—An unexpected decrease in the visible supply was an outstanding feature of the official returns of this metal for July, and was quickly followed by a fairly sharp recovery in values. According to A. Strauss & Company, the total visible supply at the end of July was 336 tons less than at the end of June, at 14,283 tons, while Ricard & Friewald give the total visible supply at 15,085 tons, or 298 tons lower on the month.

Official closing prices of standard tin have been as under :—

Cash: Thursday, £296 to £296 5s.; Friday, £296 to £296 5s.; Monday, £293 5s. to £293 10s.; Tuesday, £293 10s. to £293 15s.; Wednesday, £291 10s. to £291 12s. 6d.

Three Months: Thursday, £287 15s. to £287 17s. 6d.; Friday, £287 15s. to £288; Monday, £285 5s. to £285 10s.; Tuesday, £285 10s. to £285 15s.; Wednesday, £284 10s. to £284 15s.

Spelter.—Dealings in ordinary spelter of late have been on a moderate scale, but the demand from galvanisers remains fairly steady, and a certain amount of optimism is gaining ground with regard to trade in the autumn, when considerable orders are expected from India.

The following are the week's prices :—

Ordinary: Thursday, £28 8s. 9d.; Friday, £28 5s.; Monday, £27 17s. 6d.; Tuesday, £27 16s. 3d.; Wednesday, £27 17s. 6d.

Lead.—Values of soft foreign pig have more recently given some signs of improvement, and although reacting to below £24 at one time, have almost fully recovered the loss chiefly due to strong American cables. But there is still some little uncertainty around the market because of the large surplus of supplies held on this side.

The week's prices are appended :—

Soft foreign (prompt): Thursday, £23 7s. 6d.; Friday, £23 2s. 6d.; Monday, £23; Tuesday, £22 15s.; Wednesday, £22 18s. 9d.

BLACKING,
PLUMBAGO,
CORE GUM,
WHITE DUST,
COAL DUST.

JAS. DURRANS & SONS, LTD.
PHOENIX WORKS, PENISTONE, near SHEFFIELD.

ESTABLISHED 1863

Manufacturers of
FOUNDRY EQUIPMENTS

LADLES,
FIRE BRICKS,
STONE FLUX,
CASTING CLEANERS,
PIPE NAILS,
SPRIGS,
WIRE BRUSHES,
BELLOWS,
CUPOLAS,
GANISTER,
LOAM AND SAND MILLS,
STUDS,
CHAPLETS,
BRUSHES,
CORE ROPES,
BUCKETS,
SPADES, Etc.

Telephone :
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"DURRANS, PENISTONE."

Write for Illustrated Catalogue on Blacking and Foundry Requisites, also for our latest Price List.

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West Midland Refining Co.,

Bilston.

COLD BLAST IRONS

for Chilled Castings.

Chills and analysis guaranteed.

CHARCOAL

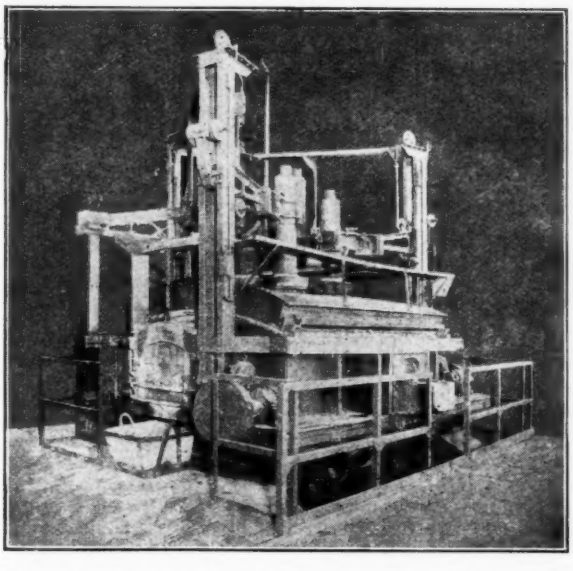
REFINED HEMATITES

for Malleable Castings.

GREAVES-ETCHELLS ELECTRIC STEEL FURNACES

MORE THAN 100 FURNACES SUPPLIED DURING LAST 7 YEARS.

WATSON ROTATING ELECTRIC FURNACES Ensure RAPID & CLEAN MELTING — THOROUGH MIXING.



NON-FERROUS METAL MELTING ELECTRIC FURNACES — SINGLE, TWO, or THREE PHASE.

CONTRACTORS TO HOME AND FOREIGN GOVERNMENTS.

WATSONS (METALLURGISTS) LIMITED

Lancaster Street, SHEFFIELD

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	55	1	3
Three months	55	7	6
Electrolytic	62	5	0
Tough	59	10	0
Best selected	60	10	0
Sheets	86	0	0
India	72	0	0
Wire bars	62	15	0
Do. September	62	15	0
Do. October	62	15	0
Ingot bars	63	0	0
H.C. wire rods	67	15	0
Off. av. cash, July 54	11	8 5/16	
Do. 3 mths. July 54	19	9 1/2	
Do., Sttlmnt. July 54	11	6 1/2	
Do., Electro, July 60	6	6 1/2	
Do., B.S., July	58	15	3 1/2
Aver. spot price copper, July	54	11	8 1/2
Do., wire bars, July	60	11	3 1/2
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			9½d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	9½d.
Wire	9½d.
Rolled metal	9¼d.
Yellow metal rods	7¼d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	291	10	0
Three months	284	10	0
English	288	5	0
Bars	292	10	0
Straits	297	0	0
Australian	297	0	0
Eastern	292	5	0
Banca	303	10	0
Off.avr.cash, July	288	16	3
Do., 3 mths., July	281	19	3 3/4
Do., Sttlmt. July	288	15	11 7/8
Aver. spot, July	288	16	3

SPELTER.

	£	s.	d.
Ordinary	27	17	6
Remelted	26	5	0
Hard	22	5	0
Electro 99.9	31	5	0
English	28	7	6
India	24	10	0
Zinc dust	37	0	0
Zinc ashes	10	10	0
Off. aver., July	28	3	0 1/16
Aver., spot, July	28	5	7

LEAD.

	£	s.	d.
Soft foreign ppt.	22	18	9
English	24	5	0
Off. average, July	23	14	2 1/2
Average spot, July	23	9	9 1/4

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	36	0	0
Do. V.M. ex whf.	34	10	0
Rods	42	0	0
Boiler plates	34	0	0
Battery plates	33	10	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	67	0	0
Chinese	52	0	0
Crude	37	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	21	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£8 15 0
45/50%	£12 10 0
75%	£19 15 0
Ferro-vanadium—	
35/40%	14/3 lb. va.
Ferro-molybdenum—	
70/75% c. free	5/- lb.
Ferro-titanium—	
23/25% carbonless	11½d.
Ferro-phosphorus, 20/25%,	£17 15 0
Ferro-tungsten—	
80/85%, c. fr.	1/4 lb.
Tungsten metal powder—	
98/99%	1/8½ lb.
Ferro-chrome	
2/4% car.	£33 15 0
4/6% car.	£23 15 0
6/8% car.	£23 0 0
8/10% car.	£22 12 6
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£42 0 0
Max.0.70% car.	£54 0 0
70%, carbonless	1/4½ lb.
Nickel—99%, cubes or pellets	£170
Ferro-cobalt	9/3 lb.
Aluminium 98/99%	£105
Metallic chromium—	
96/98%	3/- lb.
Ferro-manganese (net)—	
76/80%, loose	£12 0 0
76/80%, packed	£13 0 0
76/80%, export	£11 15 0
Metallic manganese—	
94/96%, carbonless	1/10 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 2 6
Finished bars, 18% tungsten	3 0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do. under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10% extra.

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Hvy. steel	3	0	0	to	3	2	6
Bundled steel & shrngs.	2	12	6	to	2	14	0
Mixed iron & steel	2	13	6	to	2	15	0
Heavy cast iron	3	1	0	to	3	2	6
Good machinery for foundries	3	2	0	to	3	2	6
Cleveland—							
Heavy steel	2	15	0	to	2	17	6
Steel turnings			2	4	0		
Cast iron borings			2	2	6		
Heavy forge			3	10	0		
Bushelled scrap			3	1	0		
Cast-iron scrap	3	0	0	to	3	6	0
Lancashire—							
Cast-iron scrap			3	5	0		
Hvy. wrought			3	2	6		
Steel turnings			2	2	6		

London — Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	48	0	0
Brass (clean)	38	0	0
Lead (less usual draft)	20	10	0
Tea lead	18	0	0
Zinc	18	0	0
New aluminium cuttings	80	0	0
Braziery copper	45	0	0
Gunmetal	48	0	0
Holiow pewter	170	0	0
Shaped black pewter	130	0	0

PIG-IRON

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1	70/-
Foundry No. 3	67/6
Foundry No. 4	66/6
Forge No. 4	66/-
Hematite No. 1	76/-
Hematite M/Nos.	75/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/-
,, d/d Birm.	94/-
Midlands—	
Staffs. common*	—
,, No. 4 forge	—
,, No. 3 fdry.	67/6
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	—
,, fdry. No. 3	61/3
Derbyshire forge	—
,, fdry. No. 3	67/6
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	76/6
Hem. M/Nos.	78/6
Sheffield (d/d district)—	
Derby forge	69/-
,, fdry. No. 3	71/6
Lincs. forge	—
,, fdry. No. 3	71/6
E.C. hematite	89/-
W.C. hematite	91/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	75/6
Northants foundry No. 3	—
Dalzell, No. 3	105/- to 107/6
Summerlee, No. 3	93/6 to 100/-
Glengarnock, No. 3	93/6 to 100/-
Gartsherrie, No. 3	93/6 to 100/-
Monkland, No. 3	93/6 to 100/-
Coltness, No. 3	93/6 to 100/-
Shotts, No. 3	93/6 to 100/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.) nom.	9	15	0	to	11	0	0
Angles			—				
Tees to 3 united ins.			—				
Nut and bolt iron			—				
Hoops	14	10	0				
Marked bars (Staffs.) f.o.t.	13	10	0				
Gas strip	12	10	0				
Bolts and nuts ¾ in. × 4 in.	15	5	0				
Steel—							
Ship plates	8	2	6	to	8	7	6
Boiler plts.	11	0	0				
Chequer plts.	10	5	0				
Angles	7	12	6				
Tees	8	12	6				
Joists	7	12	6				
Rounds and squares 3 in. to 5½ ins.	7	15	0				
Rounds under 3 in. to ¾ in. (Untested)	8	0	0	and upwards			
Flats, over 5 in. wide and up	9	2	6				
Flats, 5in. to 1½in.	8	2	6				
Rails, heavy	8	2	6				
Fishplates	12	10	0				
Hoops (Staffs.)	10	10	0				
Black sheets, 24g.	10	7	6				
Galv. cor. shts, 24g.	14	0	0				
Galv. fencing wire 8g. plain	12	10	0				
Billets, soft	6	0	0	to	7	0	0
Billets, hard	8	2	6				
Sheet bars	5	12	6	to	5	15	0
Tin bars d/d	5	12	6	to	5	15	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	2½
Sheet to 10 w.g.	1	2¾
Wire	1	3½
Rods	1	2¾
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	20.76
No. 2 foundry, Valley	18.00
No. 2 foundry, Birm.	17.25
Basic	20.75
Bessemer	20.26
Malleable	19.76
Grey forge	19.26
Ferro-mang. 80% d/d	90.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	43.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Skelp, sheared steel	1.80
Steel hoops	2.30
Sheets, black, No. 24	3.00
Sheets, galv., No. 24	3.85
Sheets, blue an'l'd, 9 & 10	2.25
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.25
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham & North.	
,, foundry	—
,, furnace	15/-
Other Districts, foundry	—
,, ,, furnace (basis)	12/6

TINPLATES,

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	18/3
,,	28×20, ,,	36/6
,,	20×10, ,,	—
,,	18¾×14, ,,	—
C.W.	20×14, ,,	16/9
,,	28×20, ,,	—
,,	20×10, ,,	—
,,	18¾×14, ,,	—

Terneplates 28 × 20, — per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£18/10 to £19/0
Rolled Ord.	£15/5/0 to £15/15
Nail rods	£15 12 6 to £16 0 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£6 0 0 to £6 10 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings*
Gas	67½%	45%
Water	62½%	40%
Steam	57½%	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Aug. 11	55	12	6	dec. 2/6
,, 12	55	12	6	No change
,, 15	55	3	9	dec. 8/9
,, 16	55	2	6	,, 1/3
,, 17	55	1	3	,, 1/3

Electrolytic Copper.

	£	s.	d.	
Aug. 11	62	15	0	No change
,, 12	62	15	0	,, ,,
,, 15	62	15	0	,, ,,
,, 16	62	5	0	dec. 10/-
,, 17	62	5	0	No change

Standard Tin (Cash).

	£	s.	d.	
Aug. 11	296	0	0	dec. 20/-
,, 12	296	0	0	No change
,, 15	293	5	0	dec. 55/-
,, 16	293	10	0	inc. 5/-
,, 17	291	10	0	dec. 40/-

Tin (English ingots).

	£	s.	d.	
Aug. 11	293	10	0	dec. 10/-
,, 12	293	0	0	,, 10/-
,, 15	290	5	0	,, 55/-
,, 16	290	10	0	inc. 5/-
,, 17	288	5	0	dec. 45/-

Zinc Sheets (English).

	£	s.	d.	
Aug. 11	36	0	0	No change
,, 12	36	0	0	,, ,,
,, 15	36	0	0	,, ,,
,, 16	36	0	0	,, ,,
,, 17	36	0	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
Aug. 11	28	8	9	dec. 1/3
,, 12	28	5	0	,, 3/9
,, 15	27	17	6	,, 7/6
,, 16	27	16	3	,, 1/3
,, 17	27	17	6	inc. 1/3

Lead (English).

	£	s.	d.	
Aug. 11	24	15	0	No change
,, 12	24	10	0	dec. 5/-
,, 15	24	10	0	No change
,, 16	24	5	0	dec. 5/-
,, 17	24	5	0	No change

AVERAGE MONTHLY PRICES OF MARKED BARS (SOUTH STAFFS).

	Jan.			Feb.			March			April			May			June			July			Aug.			Sept.			Oct.			Nov.			Dec.			Yearly average.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1897	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0
1898	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	7	10	0	8	0	0	8	0	0	7	11	8
1899	8	0	0	8	0	0	8	0	0	8	0	0	8	10	0	8	10	0	9	0	0	9	0	0	9	10	0	10	0	0	10	0	0	10	0	0	8	3	4
1900	11	0	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	5	10
1901	9	10	0	9	10	0	9	10	0	9	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	16	8
1902	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	5	0	8	5	0	8	5	0	8	5	0	8	5	0	8	5	0	8	7	6
1903	8	5	0	8	5	0	8	5	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	8	9
1904	8	10	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	10
1905	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	10	0	8	10	0	8	1	8
1906	8	10	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	15	10
1907	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0
1908	9	0	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	5	10
1909	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0
1910	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0
1911	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0
1912	8	10	0	8	10	0	8	10	0	8	15	0	9	0	0	9	0	0	9	0	0	9	8	0	9	10	0	10	0	0	9	10	0	9	15	0	9	1	6
1913	10	0	0	10	0	0	10	0	0	10	0	0	10	0	0	10	0	0	10	0	0	9	10	0	9	10	0	9	4	0	9	0	0	9	0	0	9	13	8
1914	8	12	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	8	10	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0	8	14	4
1915	9	0	0	9	0	0	9	3	0	10	2	0	10	15	0	11	10	0	12	0	0	12	0	0	12	0	0	12	7	6	12	10	0	13	10	0	11	5	0
1916	13	10	0	13	10	0	14	13	0	15	0	0	15	0	0	15	0	0	15	0	0	15	10	0	15	10	0	15	0	0	15	10	0	15	0	0	14	18	7
1917	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0	15	10	0
1918	15	12	6	16	0	0	16	0	0	16	0	0	16	0	0	16	0	0	16	0	0	16	0	0	16	0	0	17	0	0	17	0	0	17	0	0	16	6	3
1919	18	0	0	18	10	0	20	0	0	20	0	0	23	0	0	23	0	0	23	0	0	24	12	0	25	0	0	25	0	0	25	0	0	25	5	0	22	10	7
1920	26	17	6	27	0	0	28	0	0	30	5	0	30	10	0	33	10	0	33	10	0	33	10	0	33	10	0	33	10	0	33	10	0	33	10	0	31	10	2
1921	31	10	0	30	3	4	27	10	0	27	10	0	27	10	0	24	15	0	21	0	0	20	0	0	20	0	0	17	10	0	17	0	0	16	0	0	23	7	4
1922	16	0	0	14	17	6	14	10	0	13	10	0	13	10	0	13	10	0	13	10	0	13	10	0	13	10	0	13	10	0	13	10	0	13	10	0	13	18	1¼
1923	13	10	0	13	10	0	13	16	0	14	7	6	14	10	0	14	10	0	14	10	0	14	10	0	14	10	0	14	10	0	14	10	0	14	10	0	14	5	3¼
1924	14	10	0	14	10	0	14	10	0	15	0	0	15	0	0	15	0	0	15	0	0	15	0	0	15	0	0	15	0	0	15	0	0	14	17	6	14	17	3¼
1925	15	0	0	15	0	0	15	0	0	15	0	0	15	0	0	14	10	0	14	10	0	14	10	0	14	10	0	14	10	0	14	0	0	14	13	4			
1926	14	0	0	14	0	0	14	0	0	14	0	0	14	0	0	14	0	0	14	0	0	14	0	0	14	0	0	14	0	0	—	*		14	10	0	14	0	10½
1927	14	10	0	14	10	0	14	10	0	14	10	0	14	10	0	13	10	0	—			—			—			—			—			—			14	6	8

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